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WHY WE FORGET

WHY GARLIC CAUSES BAD BREATH

WHY E.T. HASN'T FOUND US

HOW ASTRONAUTS POO

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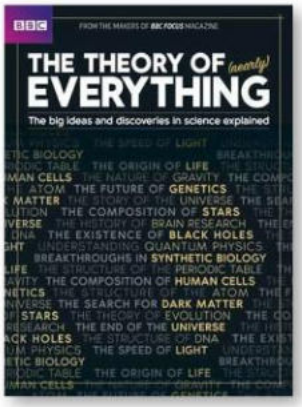
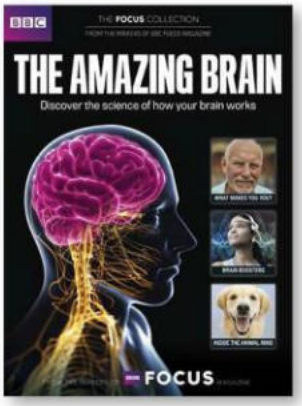
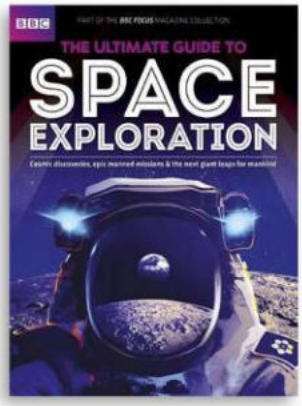


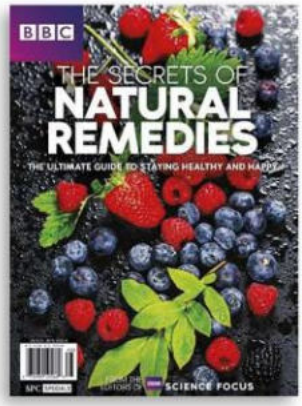
This special issue explains the fundamental concepts of science, and reveals the latest cutting edge research that will change our world.



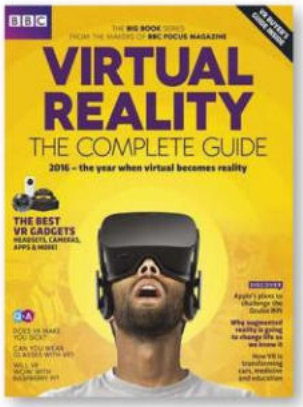
Learn about the extraordinary abilities of the human brain, the latest research into mental health, and how we can make ourselves smarter in the future.



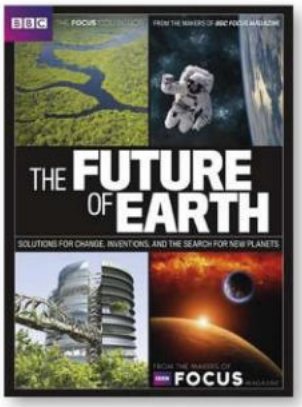
Take a trip through the cosmos to find out about the latest discoveries, epic manned missions and the next giant leaps for humankind.



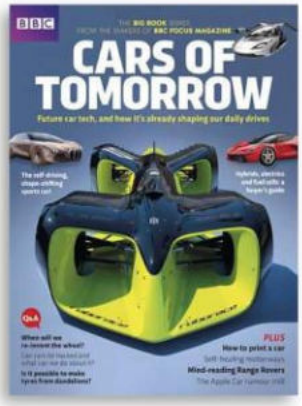
From acupuncture to yoga, argan oil to zinc, we ask scientists which techniques and treatments will help you live a happier, healthier life and which you ought to avoid.



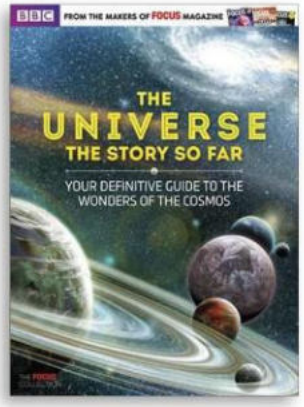
Inside: VR buyer's guide including headsets, cameras and more; the best free apps; and meet Palmer Luckey, founder of Oculus Rift.



Explore the current state of Earth, how we can protect it from global warming and natural disasters, and what would happen if we left to colonise another planet.



Featuring articles on virtual reality showrooms, how to print a car, buyer's guides to hybrid, electric and fuel cell vehicles and much more.



This special edition takes you on a journey from the pioneers who first described the Universe to the extraordinary missions exploring distant worlds today.

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Welcome

Who's on your dinner party wish list? Marie Curie? The Coen brothers? Dara O'Briain? Sandy Toksvig?...

Now, on the subject of Sandy – while she's doing an amazing job on *QI* (sorry Stephen, she is good too), she keeps saying things that simply don't tally with my usual party chat. She's constantly busting urban myths and making me question all those facts that I thought were just that – fact.

But she's not the only one. While pulling together this Q&A special issue, I discovered all sorts of facts and stats that really got my little grey cells working or simply blew my mind.

For example, did you know that the spacesuit Neil Armstrong wore to land on the Moon was made by a bra manufacturer? Or how about the fact that you'd be able to outrun a *T. rex*? (*Jurassic Park* has a lot to answer for.)

Well, over the next 90-plus pages discover more of these you've-got-to-be-joking facts and other scientific gems. Find out why tigers have stripes, whether elephants ever forget, how far sharks can smell underwater, and how quickly black mamba venom would kill you. Discover what would happen at the Big Crunch, what dark matter is, how astronauts go to the loo, and who owns the Moon. Find out how a Formula E car works and why geckos have Spider-Man-like abilities. And discover why garlic gives you bad breath and sweaty feet smell cheesy.

After soaking up this special issue, you'll be well-armed to fend off Sandy's challenges and know that you'll be the most knowledgeable bod at the party. Enjoy!

Daniel Bennett, Editor

Why do cats hate water?

Find out on p73

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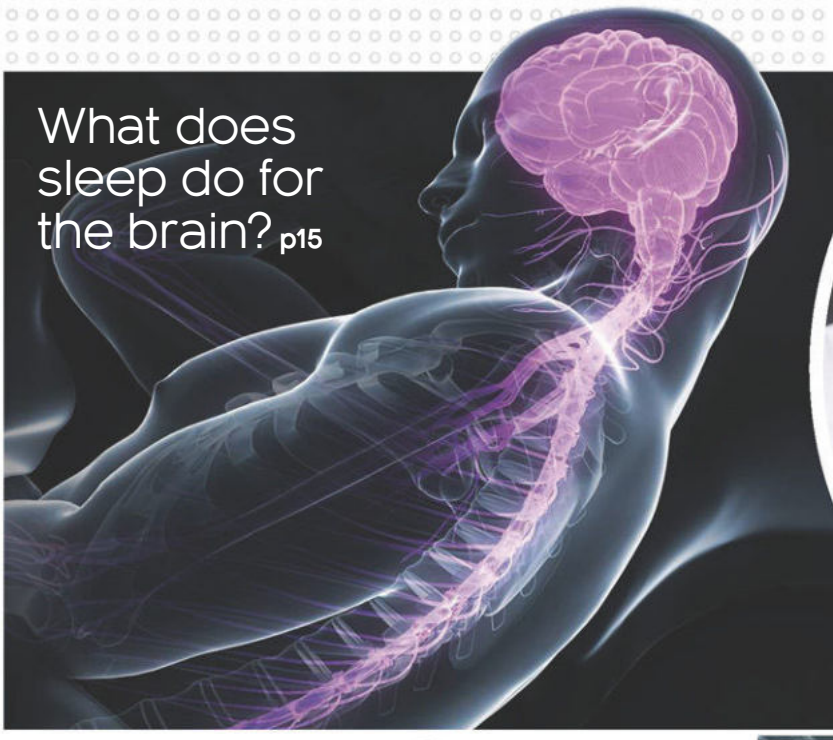
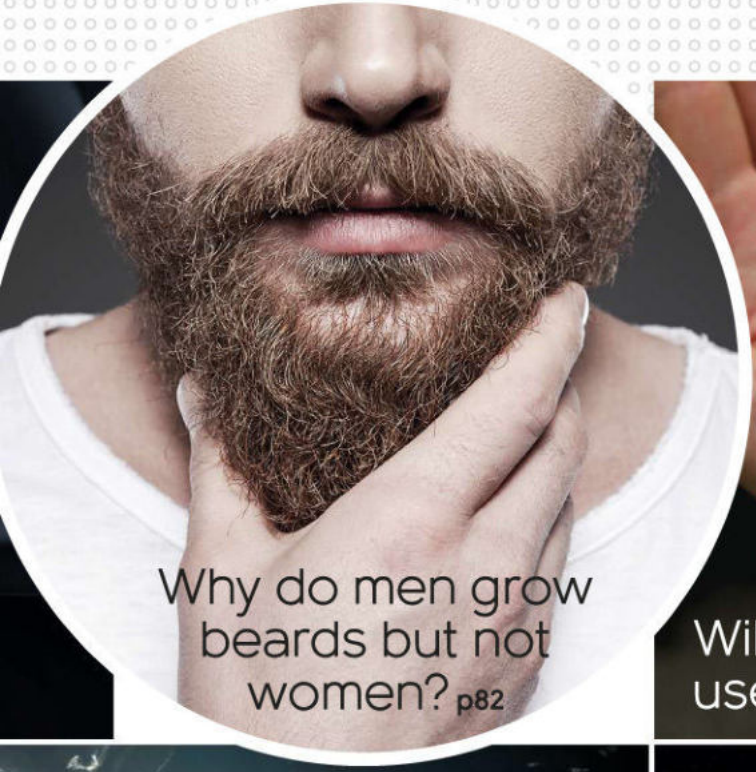


EYE OPENERS

The most incredible images: from human-made robots to towers made of people, fiery lava flows to upside down icebergs



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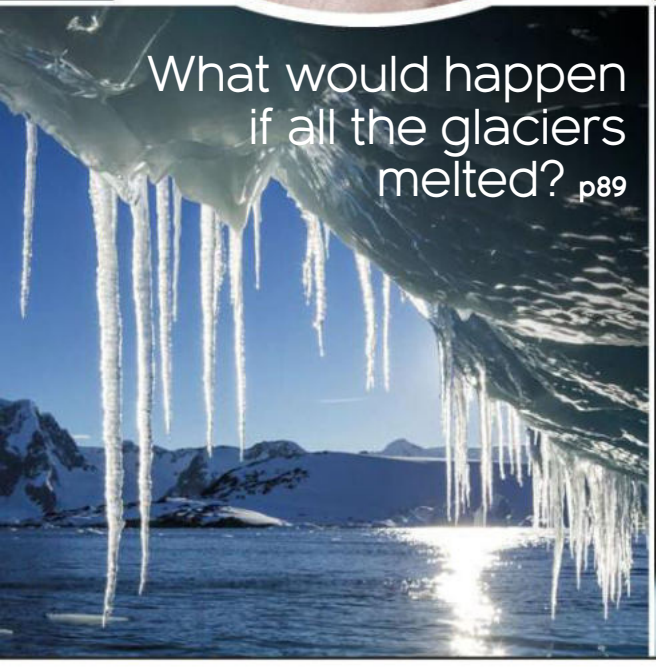


What would happen if all the glaciers melted? p89

Could an asteroid knock Earth out of its orbit? p24


REPSOL

Tower of strength

TARRAGONA

SPAIN

This colourful feat of strength is performed by people known as 'castellers', as part of a tradition that has become widespread in Catalan festivals over the last 50 years.

"The castellers forming the upper part of the tower help to stabilise each other by linking arms," says ARUP structural engineer Ben Watkins. "This means that they can hold a greater weight than if they were standing alone."

Teams aim to build the largest towers or 'castells' possible, and signify its completion when the 'enxaneta' climbs to the top and triumphantly raises a four-fingered gesture that symbolises the four stripes of the Catalan flag.

"As well as providing more support to the castellers at the base, the group surrounding the tower also acts as a cushion to lessen the fall if the tower collapses," says Watkins.

The tallest castell on record was assembled in 2015 by the team Minyons de Terrassa. With 10 levels of four people and a triple base, the tower exceeded 15 metres in height.

PHOTO: REUTERS

CAN WE UNLEARN THINGS?

To some extent, yes. Psychologists have tested this in various ways, including asking people to spend time learning pairs of words, and then asking them to deliberately forget some of them. Future memory for the deliberately forgotten words tends to be poorer. More recently, researchers have extended this concept to show that people can unlearn behavioural habits acquired in the lab (such as particular finger movements paired with specific words), and they've found that after a period of deliberately not thinking about a particular autobiographical episode from their lives, people show a loss of memory details for that episode.

Somehow, we never seem to unlearn the lyrics to the GoCompare advert...

THE HUMAN BODY

Superhuman strength, allergies, nosebleeds, memory, bad breath, phobias, wisdom teeth, suncream protection, migraines, dreams...

Wisdom teeth are now somewhat redundant

Could you survive on vitamin pills and water alone?

Definitely not. Vitamins are micronutrients. Your body needs them in small quantities to ensure optimum health, but they don't comprise the bulk of the food you need to survive. For that you need the correct mixture of carbohydrates, fats and proteins. A multivitamin tablet does normally contain a small amount of starch, and some protein in the form of brewer's yeast. But to get enough calories to survive, you would need to eat a couple of thousand tablets per day. If you tried doing that, the huge dose of vitamin A would cause liver failure, long before you noticed malnutrition from the missing fatty acids. If you stuck to the recommended dose of one or two tablets per day, you would simply starve to death in about six weeks.

WHY DO WE HAVE WISDOM TEETH?

We evolved from hominids that had longer jaws for chewing raw meat and plants. Extra molars are an advantage, but they don't emerge until adulthood, allowing the jaw time to grow large enough to accommodate them. We don't need wisdom teeth any more, nor do we have enough room for them. But dentistry offers a quicker fix than evolution.

How long does caffeine take to kick in?

Studies have found that the effects of a cup of coffee or a glass of cola are noticeable after just 10 minutes, but the peak caffeine concentration in the blood occurs after 45 minutes. For most people, the caffeine level in your body halves roughly every six hours. So 50 per cent of the caffeine from your 4pm cuppa is still circulating in your system at bedtime.

PHOTOS: GETTY X3, SCIENCE PHOTO LIBRARY

Why does reading make you sleepy?

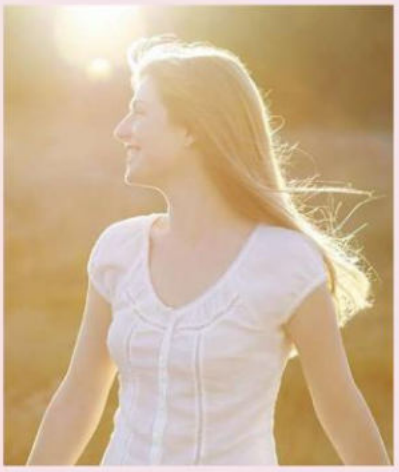
Typically when we're reading, we do it in a comfortable position – sitting or lying down – in a quiet place, and often at the end of the day or after more energetic activities, all of which contributes to a state of relaxation and sleepiness. Also, an absorbing text will take your focus away from the outside world and from anxieties that might otherwise keep us alert, such as worries about tomorrow's exam or dentist appointment. Alternatively, if you find what you're reading boring, the effort to keep going can be tiring, in which case you'll likely begin to daydream, which can also bring sleep closer.

Why does cold weather make joints sore?

There is a psychological link: people who claim the weather affects their joints do feel more pain. If weather sensitivity was a purely physical phenomenon, then people would be affected whether they believed that the variability was related to the weather or not. But a 2007 study also found that every 10°C drop in temperature resulted in worse arthritis pain. This may be because cold weather causes changes in the fluid that lubricates each joint.

DID YOU KNOW?

The average human body is estimated to contain more than 95,000km of blood vessels.



Does sunshine really make us happier?

When it's sunny, it seems like people are happier – we fill parks and beaches, and radio stations start blasting out upbeat tunes. Yet, research has repeatedly failed to find any evidence that people who live in sunnier places enjoy more positive moods. A recent survey even brought into question the idea that a lack of sunshine can lead to seasonal affective disorder (SAD). Nearly 35,000 US adults completed a mood survey at different times of year and there was no evidence of more depression symptoms among those who completed the survey in winter. Indeed, in 2016, Denmark (not sunny Spain) was ranked the happiest nation on the planet.

PHOTOS: GETTY X5

WHY DO WE DREAM?

People with damage to the brain's parietal lobe, which integrates sensory information, don't dream. One hypothesis suggests that while we sleep, the parietal lobe continues generating signals, and our forebrain tries to make a story out of this activity.

Other researchers have suggested that dreams occur when short-term memories are encoded and moved to long-term memory, or when unwanted connections are removed from memory. Evolutionary psychologists contend that dreams have a specific survival value. We mostly dream about threats or stressful situations. This may be so we can safely rehearse strategies for dealing with them.

IN NUMBERS

8.8 cm

The length of the longest nose on a living human, as measured from bridge to tip. It belongs to Mehmet Ozyurek from the Turkish city of Artvin.

TOP TEN

HUMAN PHOBIAS

SUFFERED FROM IN THE UK

=1. Arachnophobia
Fear of spiders
Proportion of population affected: 33 per cent

=1. Ophidiophobia
Fear of snakes
Proportion of population affected: 33 per cent

3. Astraphobia
Fear of thunder/lightning
Proportion of population affected: 15 per cent

=4. Trypanophobia
Fear of needles
Proportion of population affected: 10 per cent

=4. Claustrophobia
Fear of enclosed spaces
Proportion of population affected: 10 per cent

6. Odontophobia
Fear of dentists
Proportion of population affected: 9 per cent

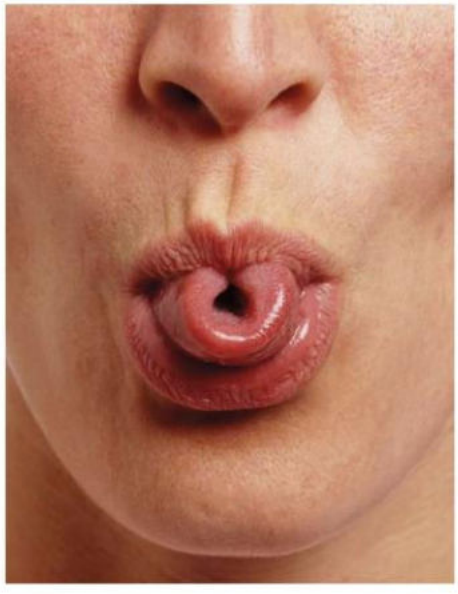
7. Aviophobia
Fear of flying
Proportion of population affected: 7 per cent

8. Acrophobia
Fear of heights
Proportion of population affected: 5 per cent

9. Cynophobia
Fear of dogs
Proportion of population affected: 3 per cent

10. Agoraphobia
Fear of public spaces
Proportion of population affected: 2 per cent

Lavender harvesting in France: the world's most relaxing job?



Why can't everybody roll their tongues?

Scientists aren't sure. There is a long-standing myth that tongue rolling is controlled by a single gene, but this was based on a single piece of flawed research and was debunked as early as 1952. Tongue rolling seems to be an ability that comes with practice. The most likely explanation is that because tongue rolling isn't useful for speaking, whistling, talking, kissing or anything else apart from showing off at parties, some of us just never got around to mastering the skill.

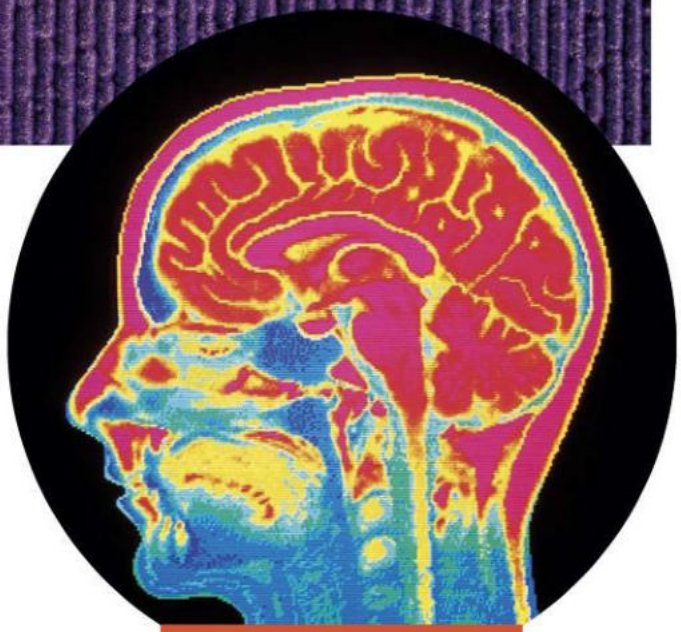
PHOTOS: GETTY X4, REX

Why does the smell of lavender help you sleep?

It's not just because it reminds you of the comforting smell of your granny's house. Lavender oil is mainly linalyl acetate and linalool, which are chemicals that are both rapidly absorbed into the bloodstream. Studies on mice have shown that these compounds inhibit several neurotransmitters and have a sedative and pain-relieving effect. In humans, lavender also lowers the heart rate and reduces anxiety.

Why do women feel the cold more than men?

Partly this is because, for a given bodyweight, women tend to have less muscle tissue to generate heat. But the hormone oestrogen also has a big impact because it has the side effect of thickening the blood slightly. This reduces blood flow to the tiny capillaries supplying the extremities. A 1998 study at the University of Utah found that this can mean a woman has hands, feet and ears that are 3°C colder than a man's.



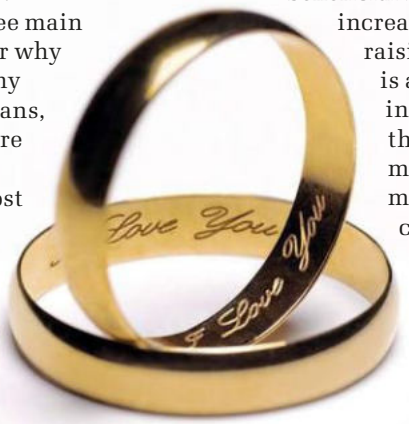
DID YOU KNOW?

While the human brain makes up just two per cent of total body weight, it uses up between 20-25 per cent of the body's energy.

Are humans naturally monogamous?

Humans aren't sexually monogamous in the sense that many birds are. Geese form lifelong couples and virtually never mate with anyone except their partner. We are termed 'socially monogamous' by biologists, which means that we usually live as couples, but the relationships aren't permanent and some sex occurs outside the relationship.

There are three main explanations for why social monogamy evolved in humans, and biologists are still arguing which is the most important. It may be because human babies need a lot of looking after and stable couples can share the parenting burden. Or it could be because men want to stay close to prevent their partners from cheating. And it could also be a strategy that women evolved to discourage men from killing infants that they suspected were not theirs. Monogamy in humans is beneficial because it increases the chances of raising offspring, but it is actually very rare in mammals – less than 10 per cent of mammal species are monogamous, compared with 90 per cent of birds.



How do we get superhuman strength in a crisis?

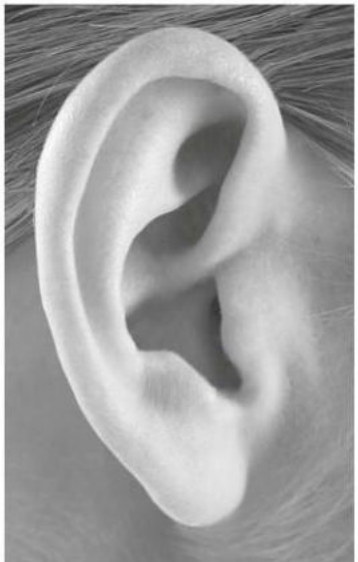
Physiologists used to think that the muscles controlled their own effort levels, shutting down when exhausted. We now know that the brain plays a much bigger part, and that fatigue signals from the muscles are weighed in the context of motivation, beliefs and expectations. When we're in a life-threatening and adrenaline-fuelled situation, it makes sense that the brain abandons its usual conservative approach and instructs the muscles to work much nearer their full capacity. But also bear in mind that many anecdotes about superhuman strength are not as incredible as they first seem. For example, it's usually one corner of a car's bulk that is briefly lifted, not its full weight.

Luckily, we don't tend to turn green when we gain superhuman strength

Why do some people get allergies?

Allergies are caused by an overactive immune system. There's evidence that this is inherited, but many studies have also shown that growing up in an excessively clean environment can trigger allergies. People from big families tend to have been exposed to more bacteria and have a lower chance of developing allergies. If you had skin cream containing peanut oil as a baby, you are more likely to be allergic to peanuts as an adult, and soy in formula milk may also trigger peanut allergies. This may be because the proteins have similar molecular shapes.

Are there different types of earwax?



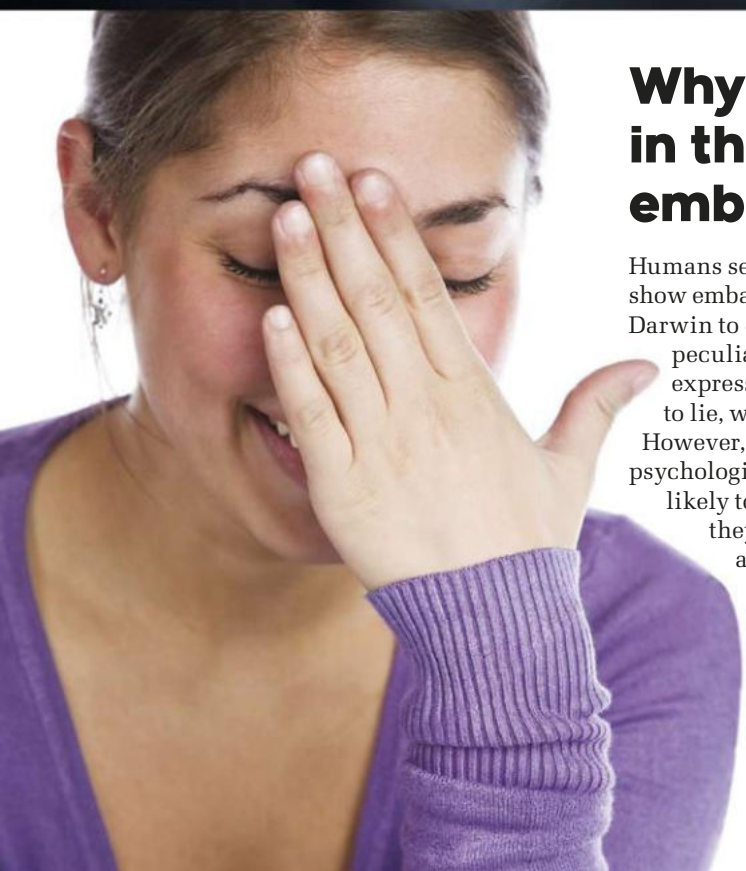
Just two. The most common, wet earwax, evolved as a way to remove dead skin cells from your ear canal. Earwax is 60 per cent skin, with various different oils binding it together in a brown lump. But there is a recessive gene mutation that results in a different mix of oils, creating flaky earwax. This is common among the Japanese and Native Americans.

PHOTOS: SHUTTERSTOCK, GETTY X5

WHAT DOES SLEEP DO FOR THE BRAIN?

Too much stimulation of your brain cells can lead to neurotoxicity, which is dangerous, and so one tentative theory holds that sleep is a chance for the brain to enter a detox mode in which overall levels of neural excitability are reduced. Sleep also helps the brain to learn, although the precise physiological processes that underlie this benefit are still being worked out. This means that after you've spent time revising or learning a new skill, it's very important that you get a good night's sleep. Doing so will help your brain to consolidate the neural connections that underlie new memories.

Research shows that sleep helps cement newly learnt skills



Why do we go red in the face when embarrassed?

Humans seem to be the only animals to show embarrassment, leading Charles Darwin to describe blushing as "the most peculiar and most human of all expressions". Blushing makes it harder to lie, which seems like a disadvantage. However, a 2009 study by Dutch psychologists found that we are more likely to give people a second chance if they blush when they betray us. The ability to blush acts as a signal that you are sensitive to the social rule you have just broken. Psychopaths, on the other hand, do not blush at all.

IN NUMBERS

100

The number of different types of bacteria grown from swabs taken from beards.

Foot cheese: not tasty on a cracker

Why do sweaty feet smell of cheese?

The same bacteria that is used to ripen many cheeses, including Munster, Limburger and Port-du-Salut, also lives on our skin and eats dead skin cells. It's called *Brevibacterium*; as it digests it gives off S-methyl thioesters, which smell cheesy. Another skin-munching bacterium is *Staphylococcus epidermidis*, which produces the cheesy, vinegary-smelling isovaleric acid. The final ingredient in this 'socktail' is *Propionibacterium*, which converts sweat into the sour-smelling propanoic acid.

WHY CAN'T WE REGROW TEETH?

Your baby teeth and adult teeth all began developing before you were even born. Our DNA still contains all the genes that sharks use to grow their endless conveyor belt of replacement teeth, but in humans these genes are deactivated by the 20th week of foetal development. The advantages of keeping the same teeth through adulthood is that they can be securely anchored in the jawbone, which allows us to chew tough plants and grains.

Why do people get hangry (angry when hungry)?

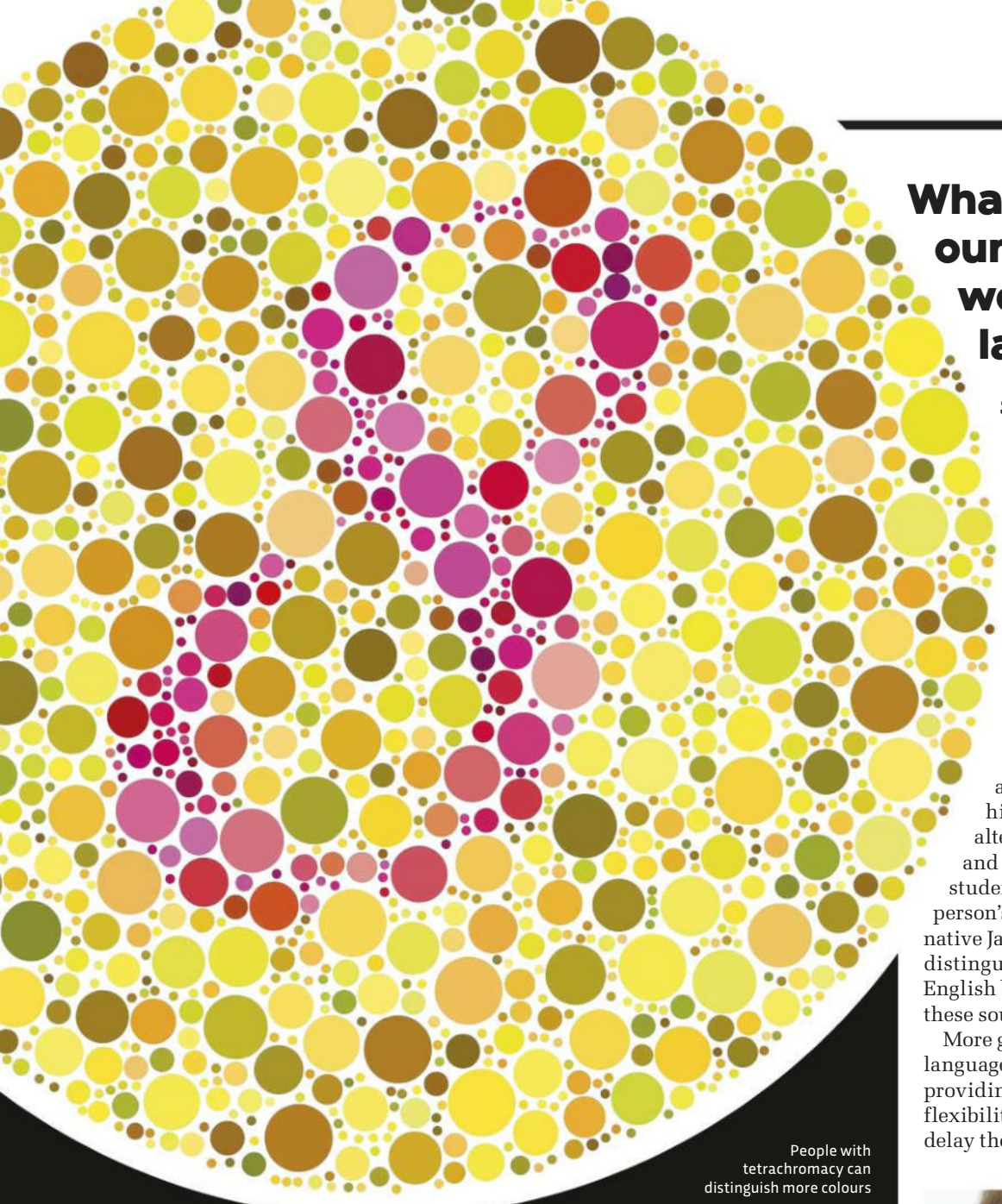
When you haven't eaten you have less glucose, meaning that your tolerance is likely to run out sooner. In one study, psychologists gave married participants a voodoo doll to represent their spouse. Each night for 21 nights, the researchers measured the participants' blood glucose levels, and told them to stick as many pins in the doll as they wanted based on how angry they were feeling. The participants with the lowest glucose levels stuck in the most pins.

IN NUMBERS

22 weeks

The approximate age of a human foetus when the brain's characteristic folds start to appear.

PHOTOS: GETTY X3, ALAMY



People with tetrachromacy can distinguish more colours

Why do people see the same colours differently?

Usually because they have more or fewer types of cone cells – the wavelength sensitive photoreceptors in the retina at the back of their eyes. Most people are trichromats, having three types of cone. Dichromats have one of the cone types missing. Men are far more prone to dichromacy than women because the genes involved are on the X chromosome, so the trait is sex-linked. Rarer still are monochromats who have two or even all three of the cone pigments missing. This is known as total colour blindness. Experiments can easily show which colours someone can distinguish, but it is not so easy to know how the colours look to them. This is really peculiar when it comes to the rare cases of tetrachromacy. These are people, mostly women, who have an extra set of cones. They can distinguish far more colours than anyone else. But what are those colours, and could the rest of us ever know what their world looks like?

What happens in our brain when we learn languages?

Specific brain areas increase in size and function, including Broca's area, which is usually in the left hemisphere and involved in language production. When children grow up bilingual, both languages are processed in the same area. Yet, when adults learn a second language, a separate area develops close to the first.

Some adults learn more quickly than others. One study showed differences in the brain areas that changed: the hippocampus and Broca's area altered most in the fast learners and the motor cortex in slower students. Some effects depend on the person's first language. For example, native Japanese speakers can't easily distinguish 'r' and 'l' when learning English because, in their brains, both these sounds activate the same area.

More generally, learning a new language improves brain function, providing better memory, more mental flexibility and creativity, and can even delay the onset of dementia.

Learning a new language improves brain function

Why doesn't everyone get acne?

Almost everybody experiences at least some acne during adolescence, but severe acne tends to run in families. How much sunshine you get or how much fatty food you eat doesn't make any difference. Whether the genetic link is because of oilier skin or different natural skin bacteria still isn't clear.

IN NUMBERS

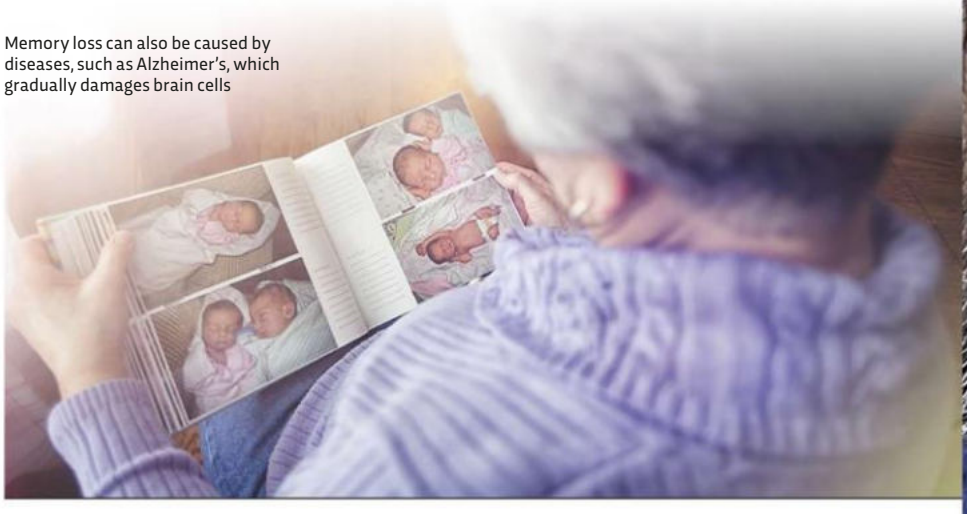
7,000

The number of blood donations taken in the UK every day. One in four of us will require a blood transfusion at some point in our lives.

WHY DO WE FORGET THINGS?

Multiple explanations have been proposed. We may forget because we didn't store the memory effectively in the first place. It is also possible that memories decay over time – because they have not been revisited, their biological 'trace' becomes weak. Another theory suggests that new memories can interfere with older ones. Or that memories have been encoded and stored, but that there is a problem with retrieval. Scientists sometimes refer to 'motivated forgetting' too, which involves forgetting an unwanted memory, such as a trauma. This is slightly controversial, as there is also evidence that such unwanted events may be particularly difficult to forget.

Of course, forgetting is not always a bad thing! It would waste cognitive resources if we remembered every single last detail of the world around us.



Memory loss can also be caused by diseases, such as Alzheimer's, which gradually damages brain cells

Why are some people so hairy?

Hair growth in humans is complicated and influenced by several different genes and hormones. The prevailing theory is that we evolved to have less hair than primates because our ancestors evolved sweating as a strategy to keep cool on the African savannah, and too much hair gets in the way of sweating. But the evolutionary reasons why hairiness varies with ethnicity are unclear. Caucasian people are generally hairier than the Japanese, for example, even though testosterone levels are the same. The difference seems to be in how sensitive the hair follicles are to those testosterone levels.

PHOTOS: GETTY X7

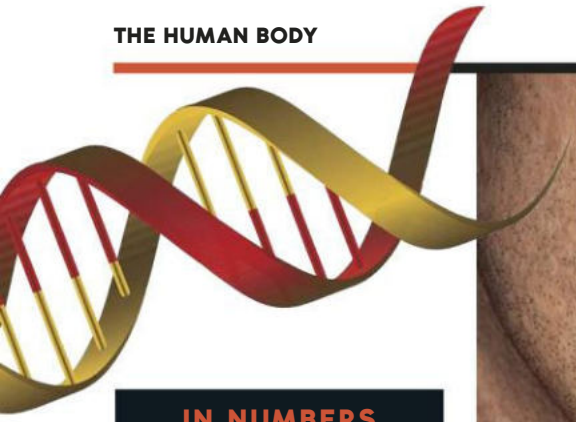
'Werewolf syndrome', or hypertrichosis, causes thick hair to grow over the body

How does suncream protect you from sunburn?

Opaque sunblocks are, effectively, paint: inorganic particles of white titanium dioxide or zinc oxide suspended in a heavy oil. The oxide particles form an opaque barrier that reflects visible light and ultraviolet. Clear suncreams use organic compounds, such as phenylbenzimidazole sulfonic acid, which protects from UVB and lets visible light through. Many creams blend inorganic and organic particles to offer good protection.

If you hold in a fart, where does it go?

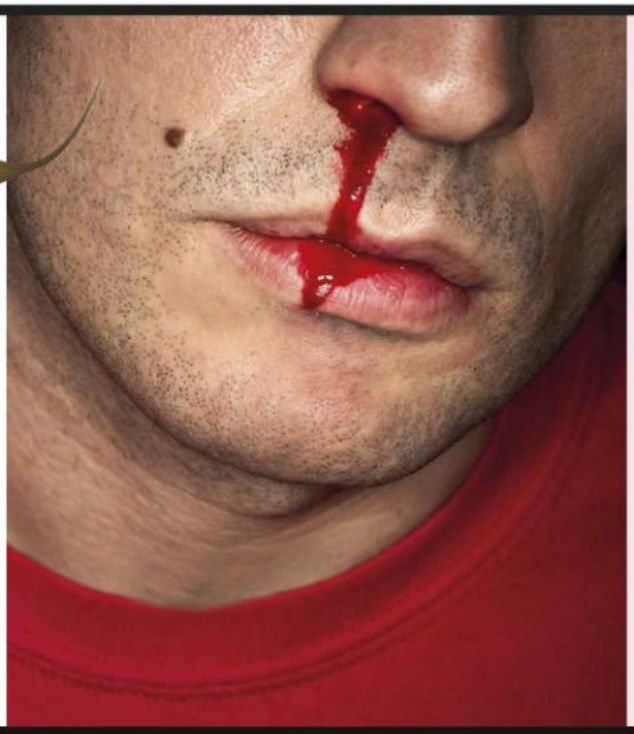
It stays right there! Fart gas mostly comes from the bacteria and yeasts that live in the large intestine. If you suppress a fart, it actually just seeps out more quietly, or you might be able to hang on until the next time you are on the toilet. But sooner or later, that fart is coming out!



IN NUMBERS

53

The percentage of a chromosome that's made up of DNA. The other 47 per cent is a sheath enclosing the genetic material.



Can you die from a nosebleed?

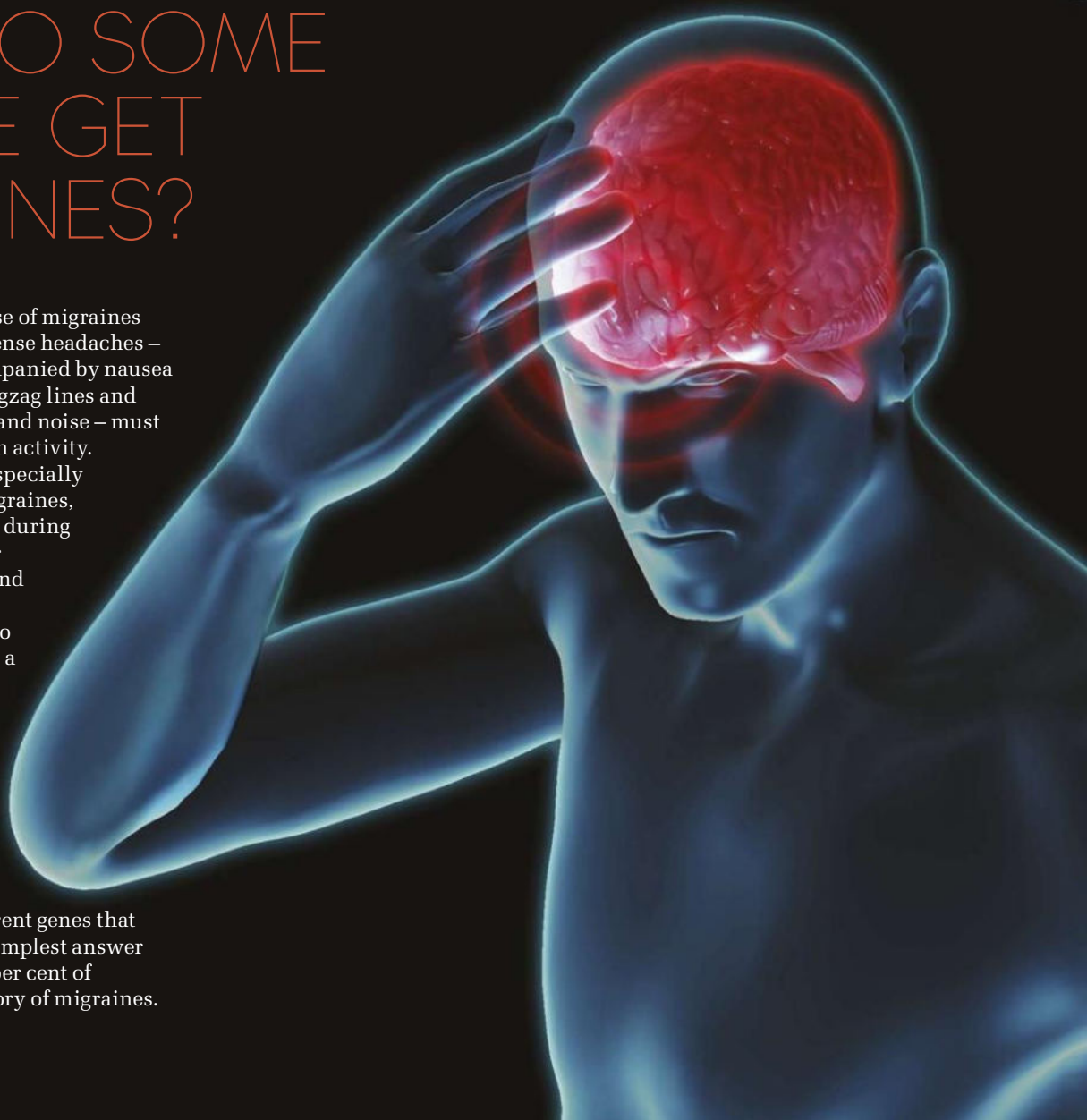
Most nosebleeds involve superficial bleeding from the capillaries close to the skin and can be stopped with pressure and an ice pack. But nosebleeds can also be caused by a torn internal carotid artery and in that case the bleeding can be fast enough to be life threatening. It's also possible for a milder nosebleed to block your airway and asphyxiate you. A 47-year-old man from Gravesend, Kent, died this way in 2011.

WHY DO SOME PEOPLE GET MIGRAINES?

Amazingly, the precise cause of migraines is still unknown. These intense headaches – often on one side and accompanied by nausea and sometimes visions of zigzag lines and extreme sensitivity to light and noise – must be caused by abnormal brain activity.

Hormonal fluctuations, especially in oestrogen, can trigger migraines, so some women suffer more during menstruation, pregnancy or menopause. Certain foods and additives can also cause migraines, while people who diet, skip meals or consume a lot of caffeine can suffer. Disturbed sleep and jetlag can also cause them.

One rare inherited type called familial hemiplegic migraine is caused by four specific gene mutations. More common types are also associated with many different genes that affect brain function. The simplest answer lies in the family. Up to 90 per cent of sufferers have a family history of migraines.



Does sucking your thumb ruin your teeth?

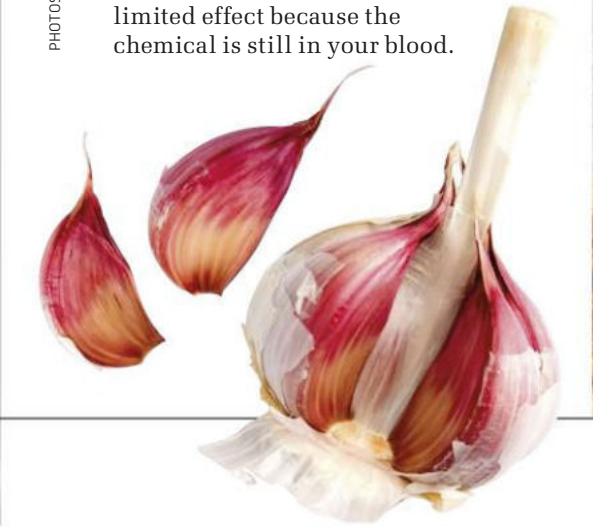
Sucking a thumb or dummy up to the age of two is fine, but several studies have shown that beyond that, there is a risk that the front teeth can be pushed outward, or the side teeth shifted so that the top and bottom sets don't meet. A 2001 study by the American Dental Association found that about 20 per cent of children who suck their thumb beyond the age of four have a misaligned bite.

WHY DO JOINTS CRACK?

A 2015 study at the University of Alberta in Canada took real-time MRI images of finger joints as they cracked. The researchers found that as the surfaces of the cartilage pull away from each other, they create a site for a tiny bubble of dissolved gas (mostly carbon dioxide) to form in the joint's lubricating fluid. The sudden expansion of the bubble creates the popping sound.

Why does garlic give you bad breath?

Garlic contains a chemical called allyl cysteine sulphoxide or 'alliin'. When a raw garlic clove is crushed or chopped, an enzyme in the garlic cells is released that reacts in a matter of seconds with the alliin to produce a chemical called allicin. This breaks down into lots of other chemicals, most of them stinky. Nearly all of these chemicals are broken down in your stomach and liver, but allyl methyl sulphide is one that survives to be absorbed intact into the bloodstream. This means that it can diffuse out through your lungs into the air you exhale for up to two days. Brushing your teeth has only limited effect because the chemical is still in your blood.

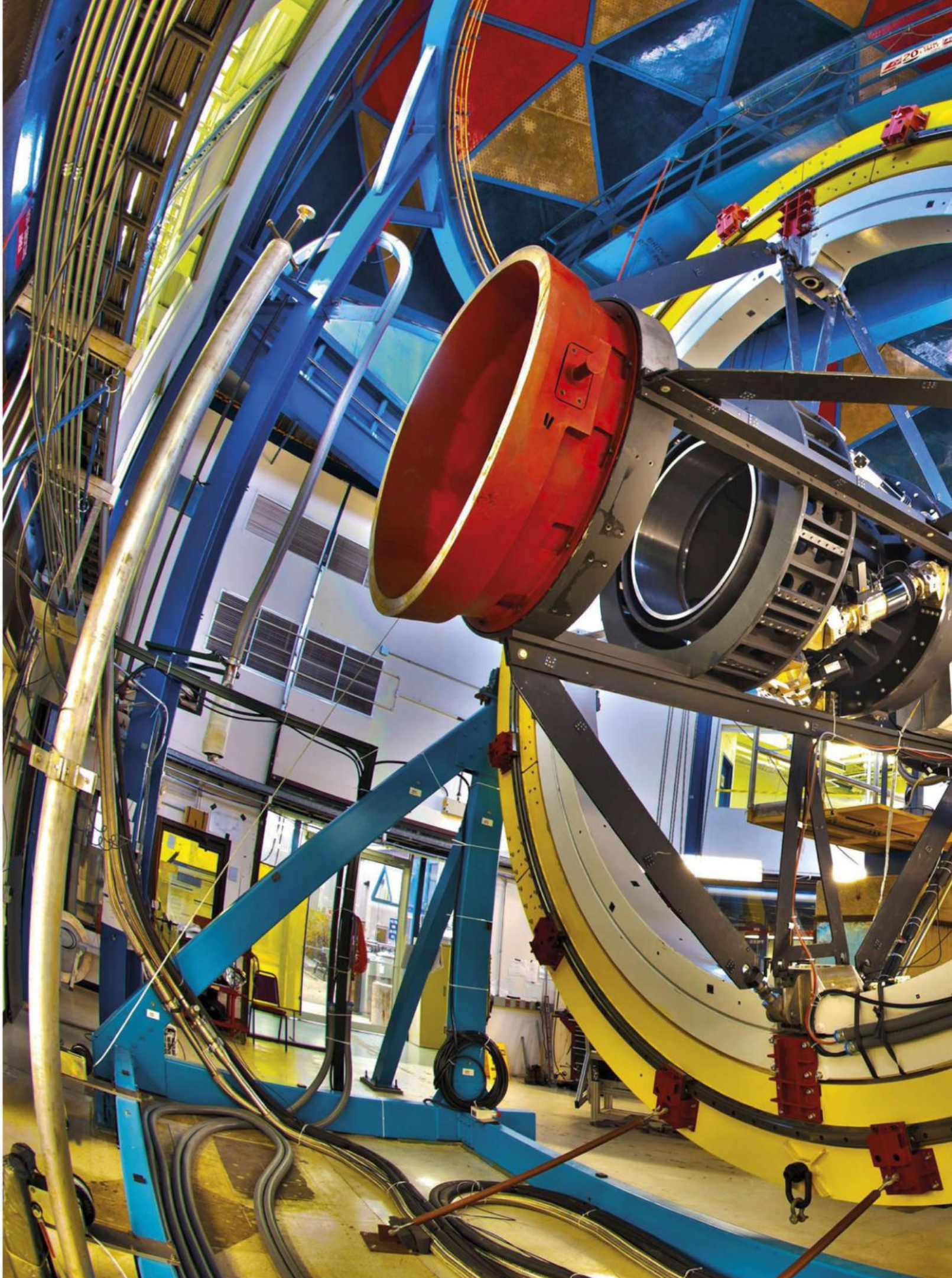


How do Inuits get their 'five a day'?

The traditional Inuit diet does include some berries, seaweed and plants, but a carnivorous diet can supply all the essential nutrients, *provided* you eat the whole animal, and eat it raw. Whale skin and seal brain both contain vitamin C, for example. But an Inuit diet isn't any healthier than a modern Western diet. Inuits have similar levels of coronary heart disease and a somewhat higher incidence of osteoporosis and stroke, since they get a higher proportion of their calories from animal fat and have limited access to dietary calcium.

A seal brain a day keeps the doctor away

PHOTOS: GETTY X5, SCIENCE PHOTO LIBRARY, ALAMY



Seeing in the dark

CTI OBSERVATORY

CHILE

If you're going to solve one of the biggest mysteries in science, you'll need a suitably impressive piece of equipment. This four-tonne digital camera at the Cerro Tololo Inter-American Observatory in Chile is tasked with revealing the nature of dark energy – the little-understood entity that's thought to be accelerating the expansion of the Universe.

The Dark Energy Camera (DECam) boasts 74 CCDs (charge-coupled devices), totalling 570 million pixels. Just like in conventional digital cameras, these convert incoming light into electrical signals. DECam, however, uses specially designed CCDs that are sensitive to the faint, redshifted light emanating from distant galaxies.

The camera is attached to the Victor M Blanco Telescope and has been carrying out a survey of the southern sky since 2013. By 2018, it will have recorded information from 300 million galaxies and thousands of supernovae, helping scientists to measure changes in the Universe's expansion (and dark energy) over the past 14 billion years.

PHOTO: SCIENCE PHOTO LIBRARY

COULD AN ASTEROID KNOCK EARTH OUT OF ITS ORBIT?

No. The Earth has a lot of mass and moves extremely quickly in its orbit around the Sun; in science speak, we say its 'momentum' is large. To significantly change the Earth's orbit, you would have to impart a very great change to the Earth's momentum. Not even the largest asteroids have sufficient mass and kinetic energy to make much of a difference to the Earth's momentum. Even more of an obstacle is the fact that our planet's binding energy is greater than its orbital kinetic energy. This means that any object large enough to change the Earth's orbit is also big enough to completely destroy it!

SPACE

Exoplanets, zero G, Interplanetary Superhighway, aliens, dark matter, space elevators, asteroids, ISS toilets, black holes...

WHAT COLOUR IS THE SKY ON AN EXOPLANET?

The colour of the sky on an exoplanet depends on many things: the pressure, density and chemical composition of its atmosphere, the presence or absence of dust particles, vapour and clouds, the spectrum of the planet's parent star, and the size, composition, colour and even biology of the planet itself. On Earth, the sky is predominantly blue but becomes orange or red near the setting or rising Sun. On Mars, the opposite is true. These differences are mainly due to which gases or compounds are scattering and absorbing the sunlight.

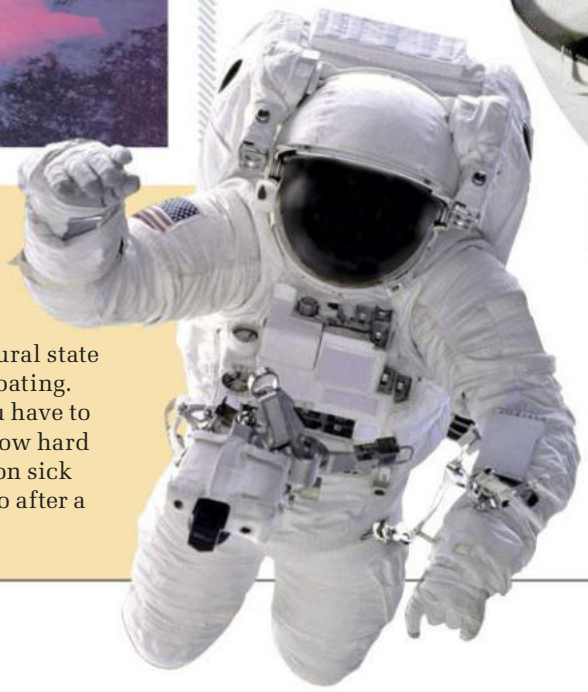
Does zero G affect sleep and dreaming?

Astronauts in microgravity environments, such as the International Space Station (ISS), have to strap themselves into a secured sleeping bag, otherwise they'd just float about. Sleep tends to be more disturbed on space missions than on Earth – this could be due to microgravity or to other factors, such as noise, excitement, stress and jet lag type problems (there are 15 dawn and dusk cycles a day on the ISS). Astronauts report having dreams but seem to need less sleep in space – around six hours rather than seven or eight. One theory is that this may be due to the physical ease of moving in microgravity.

Astronauts strap into sleep restraints when it's time to get some well-earned rest

How quickly do you get used to microgravity?

It's strange to feel weightless, but it's interesting how quickly it becomes a natural state – it only takes a few days to get used to floating. What takes longer is figuring out that you have to push off to get anywhere, and knowing how hard you need to push. Some people feel motion sick when they first arrive, but that tends to go after a day or two.



IN NUMBERS

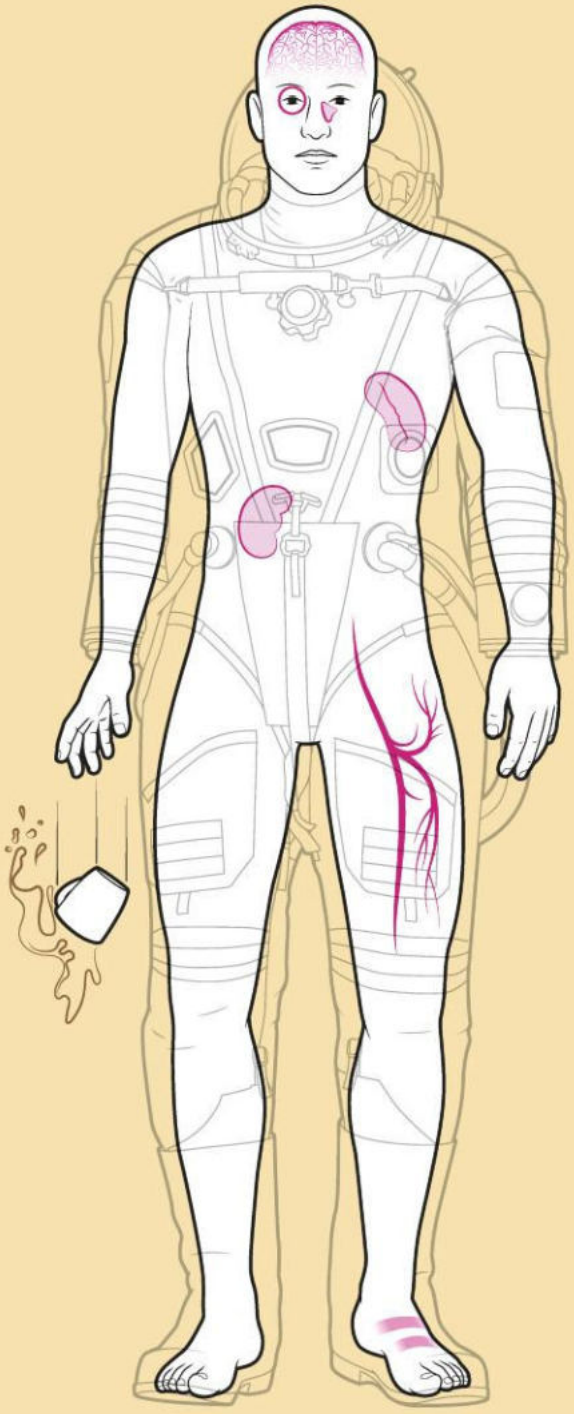
716

The number of rotations made each second by the fastest-spinning neutron star.

PHOTOS: SCIENCE PHOTO LIBRARY, GETTY X3

What happens to the body in space?

On a five-month trip to the ISS you can expect to lose 12 per cent of your bone density and 40 per cent of your muscle mass – even with daily sessions on the treadmill. This is the equivalent of ageing from 20 to 60 in a few months. Without gravity pulling it down, the fluid in your body redistributes, and your heart grows weaker. But there are some more subtle and unexpected changes too.



Brain
Mice exposed to the radiation levels typical of a journey to Mars showed more beta-amyloid proteins in their brains. This means that long space journeys could increase the chance of developing Alzheimer's disease.

Eyes
Fluid redistribution increases the pressure on the eyeball, slightly crushing the optic nerve, which can lead to visual problems later on. Increased radiation levels also raise the chance of developing cataracts.

Sinuses
Increased fluid in the head causes nasal congestion, bulging neck veins and a puffy face, which combine to feel like a constant head cold.

Mouth
Astronauts report that food tastes more bland in space, so many prefer to eat spicy food. In microgravity, gases in the stomach do not separate from liquids, so astronauts tend to have unpleasant 'wet burps'.

Coordination
Astronauts get used to things floating and their reflexes recalibrate to allow them to catch moving objects in microgravity. When they return to Earth, they are initially more clumsy and drop things.

Kidneys
Lost bone mass ends up as calcium in the bloodstream and this can precipitate into painful kidney stones.

Immune system
The T-cells in your immune system don't reproduce as well in space, making astronauts more prone to bacterial infections.

Blood
For the first few days in space your body destroys any newly produced red blood cells. This stops eventually, but your red blood cell count remains lower until you return to Earth.

Feet
The hard skin on the soles of your feet moults off because it's not in constant contact with the ground any more. But the tops of your feet become raw and sensitive from rubbing against the foot straps astronauts use to secure themselves in space.

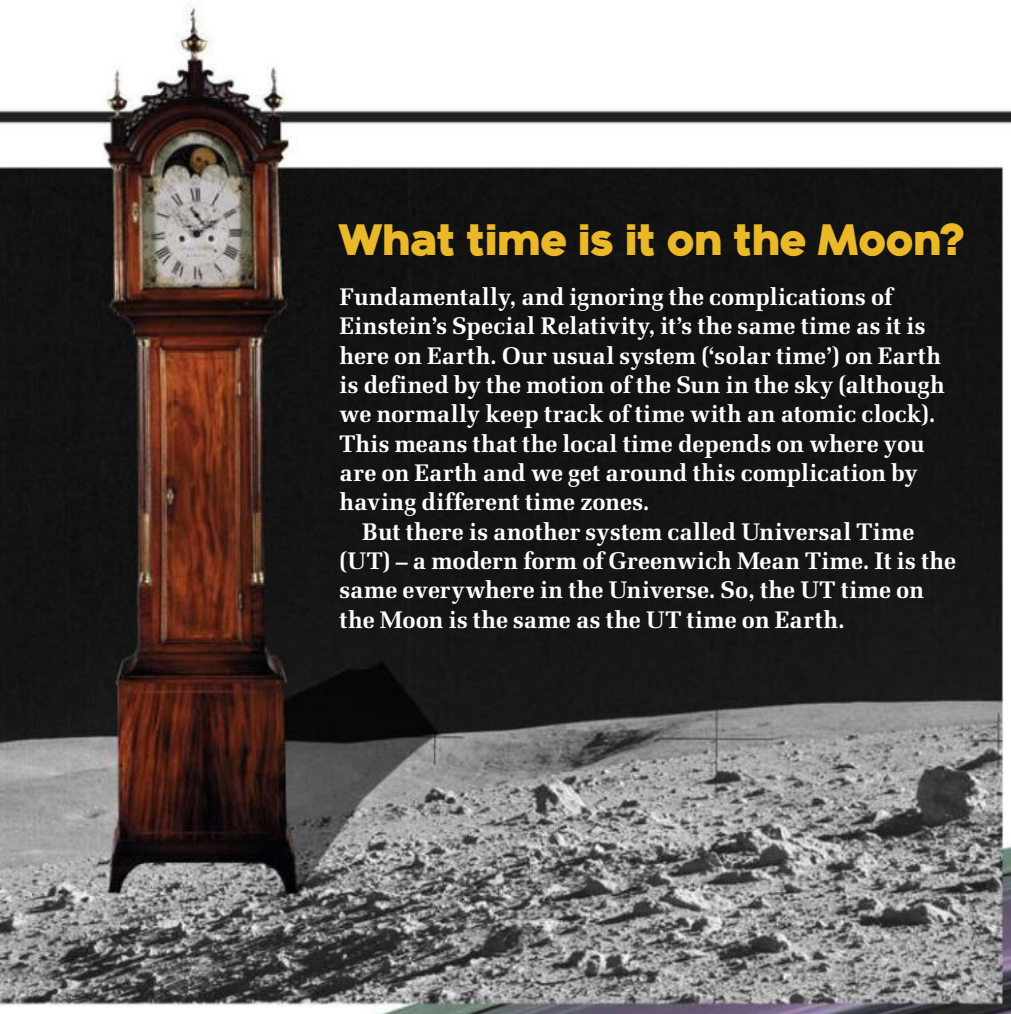
How do astronauts keep clean?

There's no shower on the ISS, so astronauts use wipes or a soapy towel. Washing hair is a little trickier. They use no-rinse shampoo, but it needs to be used with water from a drink bag. And so they have to be careful not to leave water floating around – they don't want to be shorting out electrical systems.

PHOTOS: JAMES OLSTEIN, NASA X2, GETTY

DID YOU KNOW?

A Lego figure of Galileo is currently orbiting Jupiter aboard the spacecraft Juno.



What time is it on the Moon?

Fundamentally, and ignoring the complications of Einstein's Special Relativity, it's the same time as it is here on Earth. Our usual system ('solar time') on Earth is defined by the motion of the Sun in the sky (although we normally keep track of time with an atomic clock). This means that the local time depends on where you are on Earth and we get around this complication by having different time zones.

But there is another system called Universal Time (UT) – a modern form of Greenwich Mean Time. It is the same everywhere in the Universe. So, the UT time on the Moon is the same as the UT time on Earth.

How 'intelligent' could we make space probes?

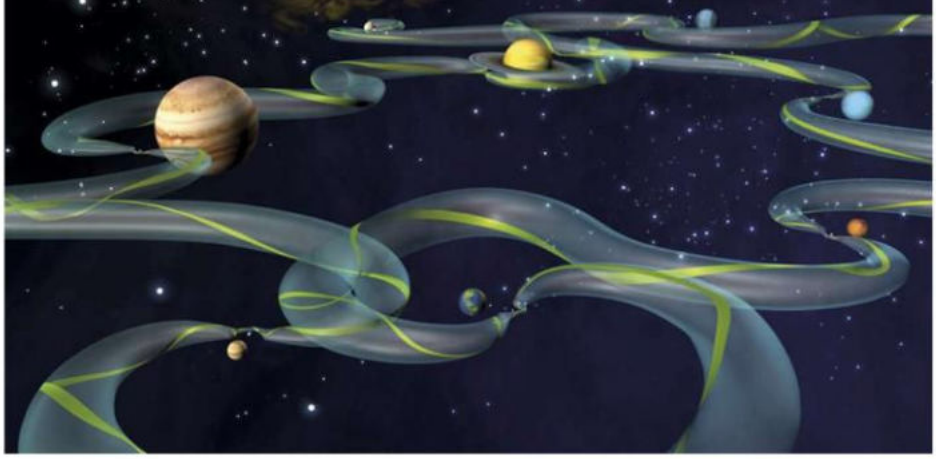
One of our biggest problems with space probes and explorer robots is that it takes time to talk to them. Depending on the position of Earth and Mars, it can take anything from four to 24 minutes for a signal to cross the void between them. It currently takes more than 17 hours for a signal to reach Voyager 1, which is our most distant probe. That may be much too slow to warn it about an impending threat. Adding some intelligence to make them more autonomous would enable them to handle such situations by themselves. An explorer robot could avoid driving into a hole, or a probe could reconfigure its electronics and recover from damage.

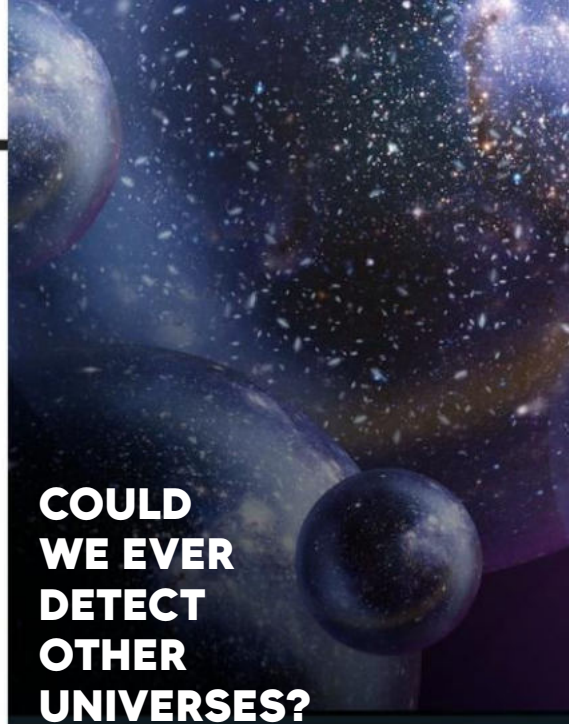
Why don't more planets have rings?

The gaseous outer planets all have rings, whereas the small, rocky inner planets do not. Scientists aren't sure how these rings came about. They may have assembled from leftover material from the planet's creation, or could be the remains of a moon that was destroyed by an impact or broken apart by the gravitational force of the parent planet. As only the gas giants have rings, the ring-forming process may be related to the same mechanism that resulted in gas giants forming in the outer Solar System, and rocky planets in the inner Solar System. The energy given off by the infant Sun expelled most of the light gases and other volatile molecules into the outer regions of the Solar System, leaving the heavier elements to form rocky inner planets. This also made it easier for the outer planets to form moons. So, the combination of large gravitational forces, the existence of volatile materials, and the shepherding of material by numerous moons probably means the outer planets were more likely to form and keep planetary rings.

What is the Interplanetary Superhighway?

Space agencies like NASA often make use of the gravitational fields of planets to give probes a boost to their final destination. In the late 1970s, mission designers began plotting out the paths between the planets and their satellites that could exploit this fuel-saving effect. The resulting ribbon-like network of celestial routes is known as the Interplanetary Superhighway, and it's now regularly exploited on missions to deep space.





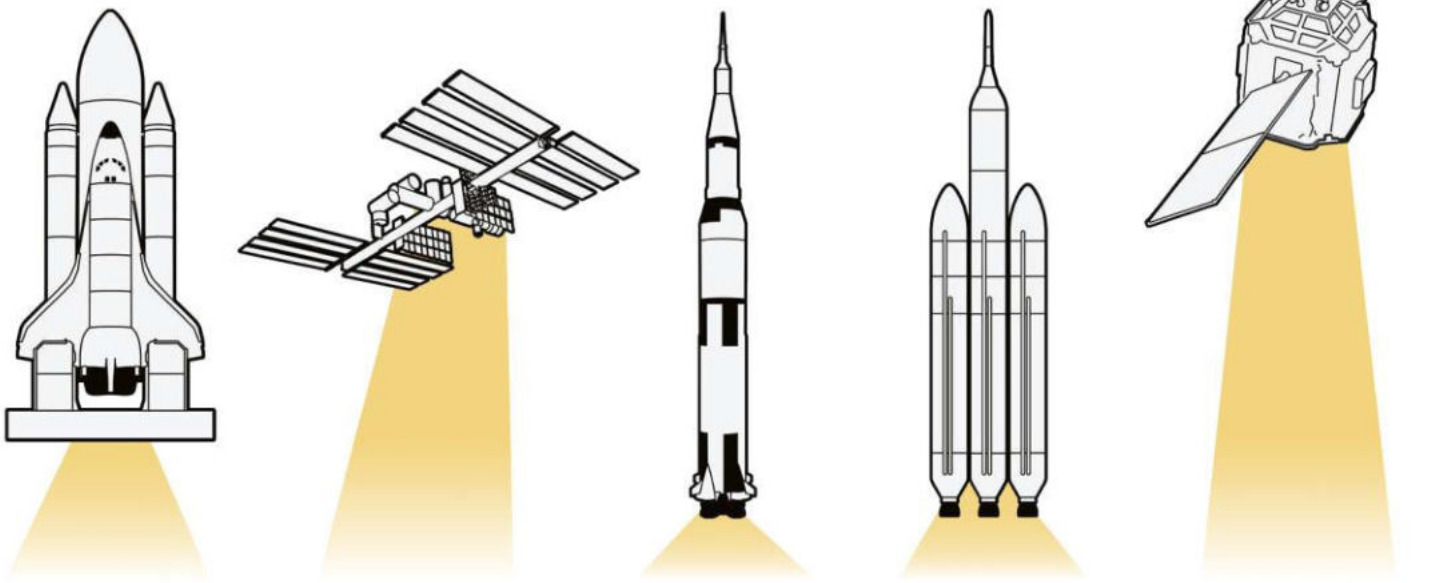
COULD WE EVER DETECT OTHER UNIVERSES?

The idea that the Universe is just one of many, making up one, truly infinite 'multiverse' is among the most intriguing – and controversial – theories in modern physics. It's based on attempts to find the one true 'Theory of Everything' (ToE) that describes all the particles and forces making up reality in a single set of equations. Some attempts to create the ToE suggest that there are myriad different universes beyond

PHOTOS: NASA, GETTY, ALAMY, CHRIS PHILPOT

TOP 10

MOST EXPENSIVE SPACE MISSIONS*



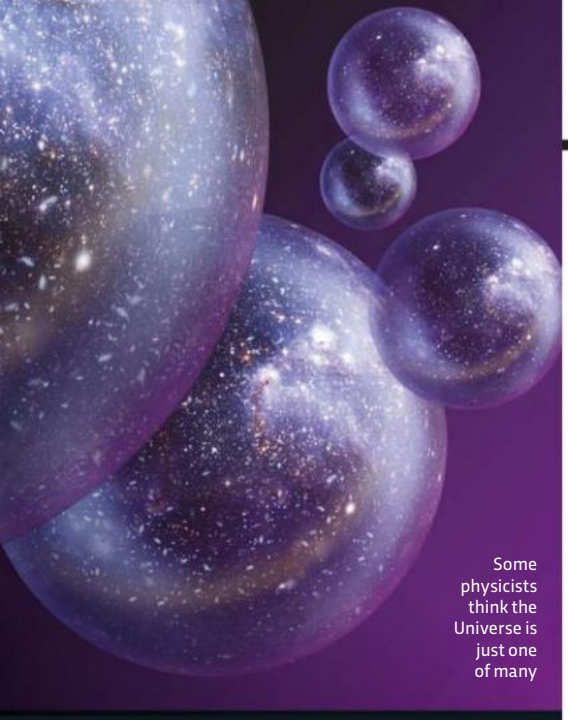
1. Space Shuttle Program
Date: 1981-2011
Cost: $199bn

2. International Space Station
Date: 1998-2020
Cost: $160bn (estimated)

3. Apollo Space Program
Date: 1961-1972
Cost: $109bn

4. SLS and Orion
(NASA's replacement manned rocket and capsule)
Date: 2014-2018
Cost: $23bn (estimated)

5. Global Positioning System (GPS)
Date: 1978-present
Cost: $12bn



Some physicists think the Universe is just one of many

our own, each with different laws of physics. According to some theorists, these differences may reveal the existence of universes neighbouring our own. Exactly how they'll be revealed is unclear, but one possibility is via distortions in the heat left from the Big Bang. This has been mapped with exquisite precision, and may contain telltale patterns consistent with the presence of another universe.

IN NUMBERS

67

The number of known moons that orbit Jupiter – but there may be more.

-13°C

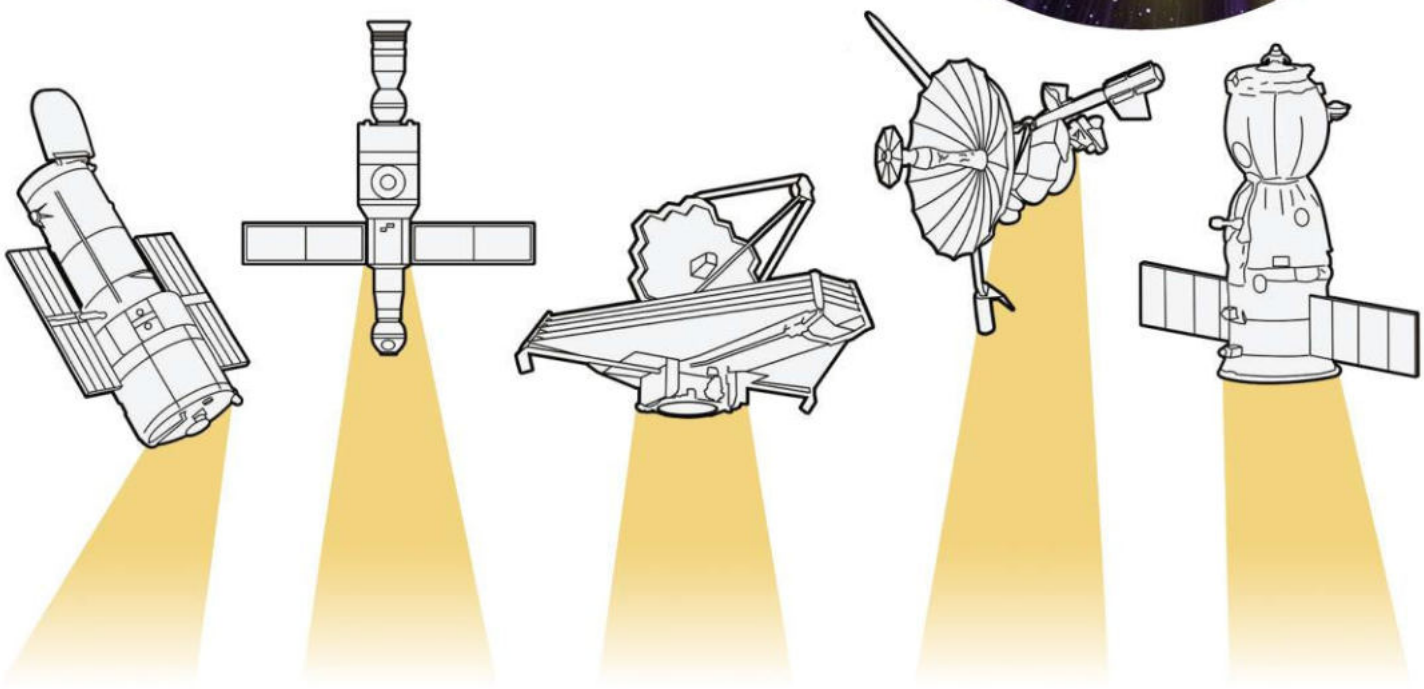
The maximum temperature of the coolest known star.

110

The speed, in km/s, at which the Andromeda Galaxy is approaching the Milky Way.

How can something explode in the vacuum of space?

Many astronomical objects such as novae and black hole mergers are known to 'explode'. This means that they energetically destroy themselves or fundamentally change, releasing matter and energy. These are quite different from many explosions here on Earth, which are feeble in comparison, and usually require oxygen to 'burn'.



6. Hubble Space Telescope
Date: 1990-present
Cost: $10bn

7. Salyut 6
Date: 1977-1982
Cost: $9bn

8. James Webb Space Telescope
Date: Scheduled for 2018
Cost: $8.8bn (estimated)

9. Galileo (Europe's GPS)
Date: 2016
Cost: $6.3bn (estimated)

10. GLONASS (Russia's GPS)
Date: 1982-present
Cost: $4.7bn

*(Figures in billions of US dollars, adjusted for inflation)

WHO OWNS THE MOON?

Officially, nobody. The issue of owning extraterrestrial space or objects is governed by the United Nations' Outer Space Treaty, first enacted in 1967. It forms the basis of international space law. Article II of the treaty states "outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means".

Is everything in the Universe expanding at the same rate?

The Universe is expanding at a rate of around 75,000km/h for every million light-years distance, on average. That might sound a lot, but it's only apparent over galactic distances, where gravity no longer dominates. Everyday objects don't take part in the cosmic expansion; if they did, there'd be no cosmic expansion, as our standard 'yardsticks' would also expand, hiding any change.

Will it ever be possible to build a space elevator?

First proposed over a century ago by the Russian astronautical pioneer Konstantin Tsiolkovsky, the space elevator offers a whole new way of getting into orbit. Instead of using rockets, electric lifts travel up a cable anchored at the Earth's equator and extending up to an orbiting counterweight whose motion keeps the cable taut.

But while simple in concept, the practicalities are immense. Chief among them is the need for a cable material that's capable of withstanding the colossal tension. It's long been thought that carbon nanotubes would be up to the job, but new research by a team at Hong Kong Polytechnic University has shown that a single misplaced atom in the cable could radically undermine its strength. With no real prospect of creating a defect-free cable, the search is now on for more robust materials.

PHOTOS: SCIENCE PHOTO LIBRARY X2, NASA, GETTY

DID YOU KNOW?

The spacesuit worn by Neil Armstrong for the 1969 Moon landing was made by a bra manufacturer.

Why hasn't intelligent alien life found us?

Sceptics have a simple answer: intelligent aliens have not contacted us because they don't exist. But others argue that, given the enormous size of the Universe, it's pretty much guaranteed that intelligent life must be out there somewhere. Maybe so, but there's no guarantee it exists nearby, or has learned of our existence through the 'leakage' of our TV and radio signals into space. So unless they've found a way of travelling far faster than the speed of light, we might be in for a long wait until they get here. Alternatively, perhaps they're already here and we're just too stupid to realise.

Can moons have moons?

There is no reason why a moon could not have a moon. But for such a 'sub-moon' to survive for any length of time, it would require a stable orbit around its parent moon. This generally means that the sub-moon would have to be quite small and orbit quite close to the parent moon. The bigger the sub-moon is and the further it is from the parent moon, the more likely it will be influenced by the gravitational attraction of the parent planet. Tidal forces can also easily prevent a stable orbit being possible. So, moons of moons are possible but probably extremely rare.

Moons of moons are probably a rare phenomenon

Aerospace engineer Dava Newman developed this BioSuit for Mars missions. Its tight, elastic structure counteracts lower pressures

Have spacesuits changed much?

Yes. The earliest spacesuits were essentially just airtight versions of the flight suits that pilots wore. In 1965 cosmonaut Alexei Leonov almost became stranded during the first spacewalk, when his spacesuit ballooned out so much from its internal pressure that he couldn't move or operate the airlock door. To avoid this, the A7L suits developed for the Apollo missions used constant-volume joints and added a self-contained air recycling unit and 100m of piping to pump cooling water around the suit. Each astronaut needed three suits (for training, flight and a spare), costing around $500,000 each. The EMU and Russian Orlan suits, currently used on the ISS, are modular to keep costs down. As they are only used in microgravity, they can be much heavier with a rigid upper torso, which offers better protection and comfort. For future missions to Mars, NASA is developing the Z-series suits that have rigid joints with titanium bearings to allow the greatest flexibility. These are the first spacesuits that allow the wearer to touch their toes, and they also have a built-in airlock.

Seeing double: Tattooine orbited two suns

In an infinite universe (or a quantum world), does the world of *Star Wars* exist in a galaxy far, far away?

An infinite universe doesn't guarantee every possible combination of atoms exists somewhere. The universe we can see could be a tile that's endlessly repeated across an infinite bathroom floor, without any variation. Or it could be that the density of matter tapers off forever but never quite stops, so after a while it drops to just one proton every billion cubic light-years; the only region that is dense enough for stars and galaxies to exist is the middle part we live in. If quantum physics allows parallel universes, and there are an infinite number, then it's entirely possible that one of them contains the galaxy depicted in *Star Wars*. But again, it's not inevitable. Imagine the roll of a die across infinite parallel universes. Every possible result will occur somewhere, including the die balancing on one of its edges. But you'll never roll a seven. Some outcomes are just impossible.

PHOTOS: NASA X2. SCIENCE PHOTO LIBRARY X2. SHUTTERSTOCK. GETTY

Is a black hole really a hole?

No. A black hole is an extremely dense object from which nothing, not even light, can escape. Hence, it is invisible – or 'black' – although it can be detected by its effect on the material around it. The term 'hole' was used because whatever falls 'into' a black hole is trapped forever. Science fiction often depicts black holes as portals between different parts of the Universe, different times or different universes altogether. This may be why it is often misconstrued that black holes are 'holes' in space-time. But, in 1935, Einstein and Rosen proposed 'wormholes' through space-time, which could provide a means of traversing large distances instantaneously. But a naturally occurring black hole doesn't form a wormhole by default. In fact, there are doubts they could occur naturally, remain stable for more than a fraction of a second, or be anything bigger than vanishingly small.

WHAT CAUSED THE BIG BANG?

The Big Bang is the moment that space and time (or 'space-time') came into existence. Before the Big Bang there was no space or time. So, it is actually meaningless to ask what caused the Big Bang to happen – there was no universe in which that cause could have existed. This might seem like a bit of a cheat, but there are other good reasons to suppose a cause for the Big Bang might not exist. Quantum physics has shown us that some events have no cause at all. Things can happen randomly, spontaneously, and for no particular reason. This unpredictable and 'causeless' nature of the Universe is experimentally verified but has nothing to do with our inability to observe correctly – it is a fundamental property of the Universe. So, although there may have been a cause for the Big Bang that we are unaware of, modern cosmology neither defines nor requires one.

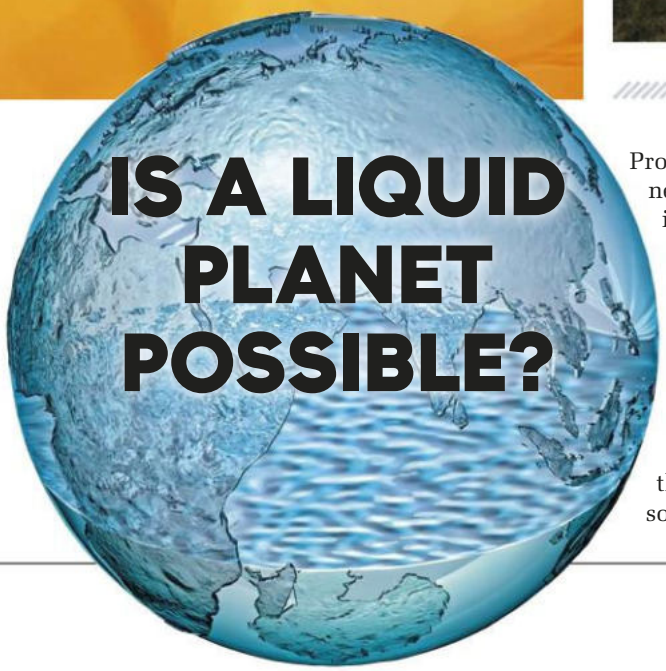
Are many visible stars dead?

Probably not. All of the stars you can see with the unaided eye lie within about 4,000 light-years of Earth. But the most distant ones are intrinsically brighter, have more mass and are therefore likely to die in rare supernova explosions. We can only see fainter (and hence less massive) stars out to smaller distances and these stars are more likely to end their lives in less violent but more common deaths. This complicates the estimate of the 'death rate' for visible stars. But we can choose an intermediate distance, say 1,000 light-years, to estimate this number. Using our knowledge of the death rate in the entire Milky Way, the death rate for visible stars works out at about one star every 10,000 years or so. Given that all those stars are closer than 4,000 light-years, it is unlikely – though not impossible – that any of them are already dead.

IN NUMBERS

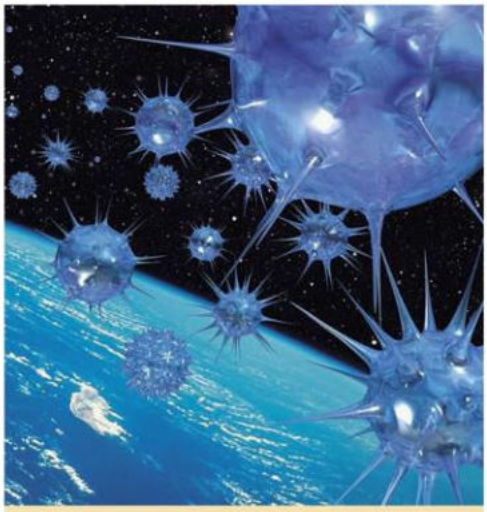
2,100

The speed, in km/h, of recorded winds on Neptune.



IS A LIQUID PLANET POSSIBLE?

Probably not entirely liquid. A planet needs to be 'self-gravitating' to keep its spherical shape under gravity. So it requires a substantial amount of mass, which means the pressure and temperature in the inner regions are usually high. The difference between the interior and exterior means that matter cannot exist in a single state, and there will always be regions where the material is vapour or solid. But a solid core could be covered by liquid.



COULD WE SEED LIFE ON ANOTHER PLANET?

Quite possibly – and preventing it from happening has long been a key concern in space exploration. In 1964, the Committee on Space Research required that nations take care to sterilise space probes to minimise the risk of contamination by Earth-based organisms. As a result, probes are routinely treated with heat, radiation and disinfectants before launch.

What does space smell like?

We can't smell space directly, because our noses don't work in a vacuum. But astronauts aboard the ISS have reported that they notice a metallic aroma – like the smell of welding fumes – on the surface of their spacesuits once the airlock has re-pressurised. The Rosetta spacecraft also detected compounds responsible for the smell of rotten eggs, bitter almonds and cat urine, boiling off from the surface of comet 67P/Churyumov-Gerasimenko.

If you fell into a black hole, would time feel really slow?

No, because you have no way of 'feeling' the passage of time. It is true that large gravitational forces slow down time, but you can only be aware of this by comparing your experiences with someone far away from the black hole. You will see a distant friend 'sped up' rather than feel yourself 'slowed down'. They will see you 'slowed down' rather than feel themselves 'sped up'. The closer you approach the black hole's 'event horizon' the more sped up you see your friend. But for you, time would 'feel' just as it does to you right now.

WHAT IS DARK MATTER?

No-one really knows, but it makes up over 80 per cent of matter in the Universe. It has to be more exotic than standard atomic particles to satisfy the chemical make up of the Universe. One candidate could be weakly interacting massive particles ('WIMPs') and gravitinos, as predicted by theories aimed at unifying all fundamental forces and particles. The other main contenders are axions, predicted by theories of how atomic nuclei hold together.

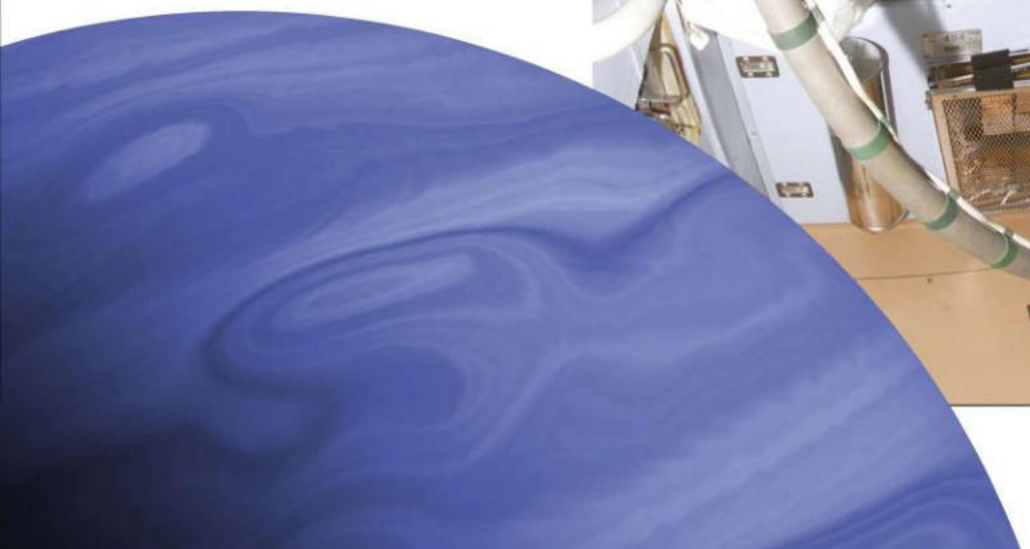
IN NUMBERS

90 per cent

The amount of sunlight reflected by Enceladus. It is the most reflective object in the Solar System.

Could Earth have been a gas giant?

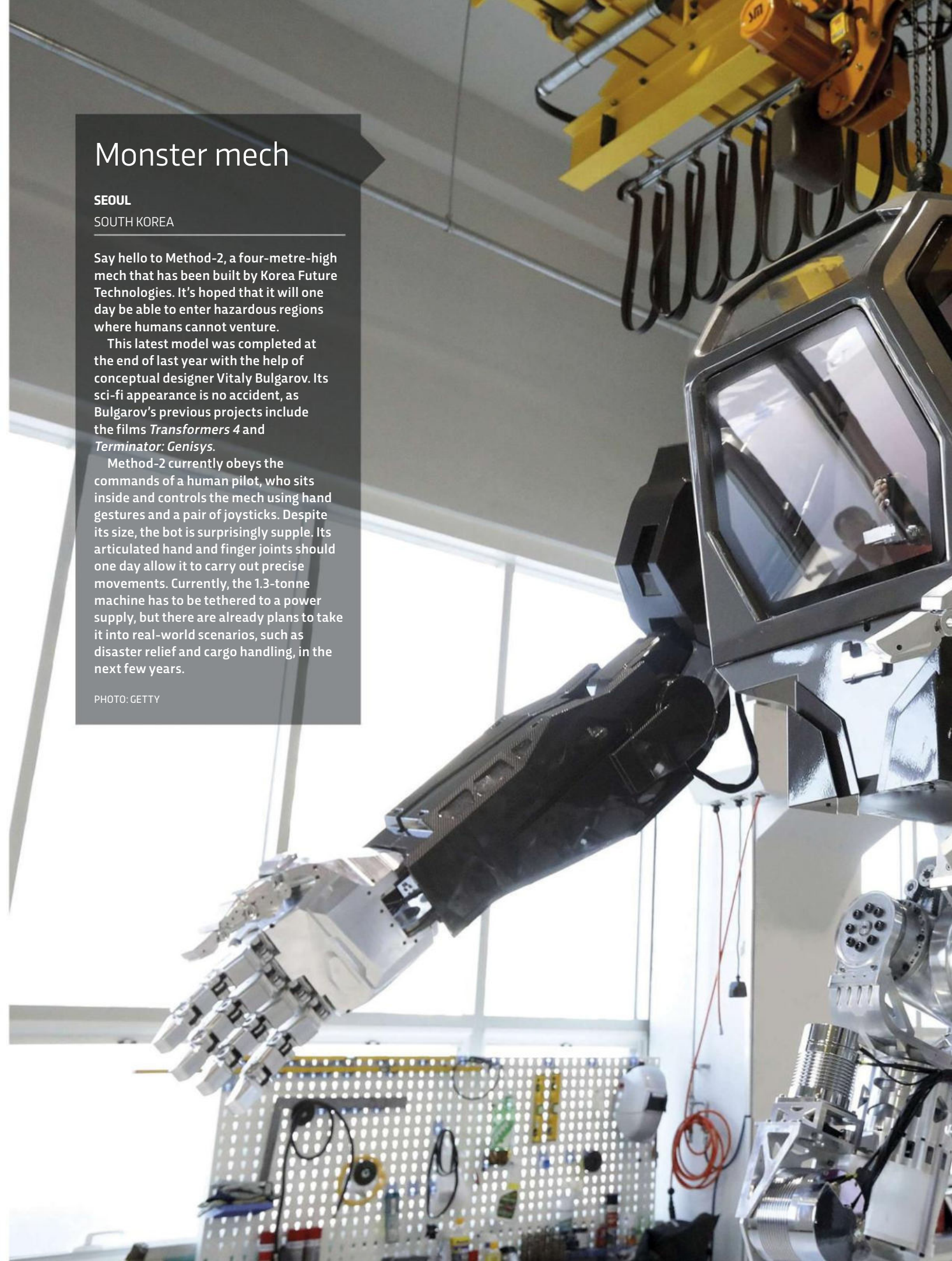
The traditional view of planet formation is of a gas cloud collapsing, fragmenting and condensing into planets, with gas giants generally forming far away from the star where more volatile compounds are found. But, another process, called 'tidal downsizing', envisages larger gas clouds forming much further out from their stars. These coalesce into massive gas giants, with sizeable rocky cores, and then migrate inward towards the parent star, eventually losing their gaseous envelopes. Although the theory is in its infancy and much of the details remain to be worked out, there is a possibility that the Earth could have formed from a gas giant in this way.



HOW DO ASTRONAUTS GO TO THE LOO?

For 'number ones', they use a funnel attached to a hose that is connected to a fan that generates suction. For solids, they 'dock' themselves carefully over a hole about the size of a drain pipe and clamp their feet into the foot restraints. Waste is caught in an individual bag liner, which they seal after use and the package is sucked into a collection drum.

PHOTOS: SCIENCE PHOTO LIBRARY X2, GETTY X2, NASA



Monster mech

SEOUL

SOUTH KOREA

Say hello to Method-2, a four-metre-high mech that has been built by Korea Future Technologies. It's hoped that it will one day be able to enter hazardous regions where humans cannot venture.

This latest model was completed at the end of last year with the help of conceptual designer Vitaly Bulgarov. Its sci-fi appearance is no accident, as Bulgarov's previous projects include the films *Transformers 4* and *Terminator: Genisys*.

Method-2 currently obeys the commands of a human pilot, who sits inside and controls the mech using hand gestures and a pair of joysticks. Despite its size, the bot is surprisingly supple. Its articulated hand and finger joints should one day allow it to carry out precise movements. Currently, the 1.3-tonne machine has to be tethered to a power supply, but there are already plans to take it into real-world scenarios, such as disaster relief and cargo handling, in the next few years.

PHOTO: GETTY

The Taranis drone: expected to enter military service in 2030

WHAT ARE THE MOST SOPHISTICATED DRONES CAPABLE OF?

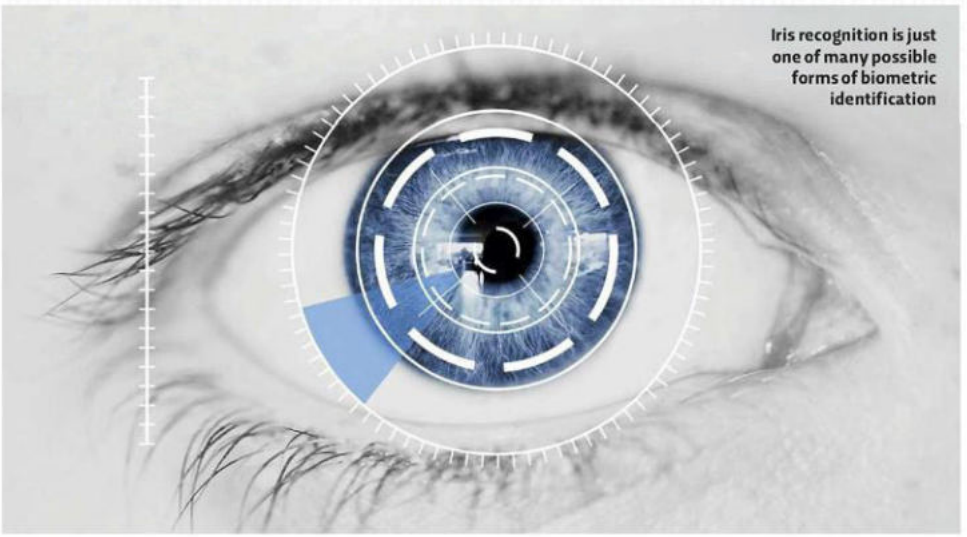
Drones are radio-controlled flying gadgets with several propellers that may be used for filming, racing, and in the future perhaps even widespread delivery of parcels. Military drones resemble small aircraft with no pilots. Some can take off, fly and land by themselves. They can perform surveillance over enemy territory or even deploy missiles to attack specific targets in dangerous places where we may not want to risk human pilots. One of the most advanced today is the Taranis, a UK-built drone with a top speed of 1,127km/h (700mph) and 9.7m wingspan that is nearly invisible to radar.

TECHNOLOGY

Drones, Formula E, robot exoskeleton, Internet of Things, supercomputers, biometric ID, data security, 3D printers...

Would it be possible to make a new internet?

The internet dates back to ARPANET, a computer infrastructure built in the 1960s by the US Defense Department to link research labs around the country. These days, the net is a sprawling collection of servers and computer systems around the world. For a network to be part of the internet, it must exchange information according to internationally agreed protocols. Being a network of networks, one can think of the overall internet as a mosaic of mini-internets. So private networks, or 'intranets', might qualify as a 'new' internet: they're self-contained internets based on the same protocols as the wider net.



Iris recognition is just one of many possible forms of biometric identification

What is the most accurate type of biometric identification?

Biometric technologies recognise you in some way, acting like a password to give you access to a computer system or security system. Some listen to your voice or examine your signature, some read fingerprints or measure faces, some examine retinas or study your brainwaves, some even measure the geometry of your hands or the shape of your ears. In a DNA profiling test only tiny parts of your DNA are examined, and samples can easily be contaminated with other DNA, so it might only be accurate to one in a few thousand. The most accurate approach will always be to use several methods in combination.

PHOTOS: BAE SYSTEMS, GETTY

HOW ACCURATE ARE FITNESS TRACKERS?

Using accelerometers worn on your wrist, waistband or shoe, they count your strides and convert that to an approximate distance travelled and calories burned. Some also include altimeters, giving you extra credit for climbing stairs and hills. But a 2014 study found that most fitness trackers have error margins of between 10-20 per cent.

IN NUMBERS

7 million

The number of drones forecast to be sold in the US in 2020.

What's the difference between viruses, trojans and worms?

A virus is a nasty piece of software that is inserted into a normal piece of software, just like a biological virus infects a cell. When the normal software is run, the virus copies itself into other software while also doing unwanted things, such as recording keystrokes to steal passwords. A trojan is similar, but it does not replicate itself. It hides inside a seemingly innocuous program – run the program and the trojan wreaks havoc, from deleting your files to giving hackers access to your system. A worm is an independent program that replicates on its own, typically spreading across networks and causing major disruption to systems.

PHOTOS: CHRIS PHILPOT, TU DELFT, ALAMY X2, GETTY X3

DID YOU KNOW?

The first computer mouse, invented by engineer Doug Engelbart in California in 1964, was carved from wood.

HOW CAN WE MAKE CARS MORE ENERGY EFFICIENT?

Common CAPTCHAs have been around since 1997

Why can't computers complete CAPTCHAs?

On a website's login page, CAPTCHAs are those obscure-looking characters we use to verify that we are human users and not bots. Optical character recognition software struggles to pick out the individual letters or numbers, especially when their shape and size vary from one CAPTCHA to the next.

Is hacking getting harder?

Computer security is becoming more and more advanced, and computer systems are complicated, so it is a more difficult task to attack or intrude into well-established computer networks. In this respect, hacking is more difficult and requires greater expertise compared to 20 years ago. However, there are more and more internet-enabled devices in the world, many of which run relatively simple software. Therefore, there are endless opportunities for hackers to exploit the security loopholes in central heating controllers, smartwatches, websites, smartphones, games consoles, CCTV cameras, vehicle controllers or even electronic toilets.

The team behind Ecorunner V wants to drive the vehicle from Amsterdam to Moscow and back on a litre of fuel

If you ask The Delft University of Technology student engineers behind the Ecorunner V (pictured), they would say that reducing drag is a big part of the answer. Theirs is the most aerodynamic car ever, with a record-breaking drag coefficient of 0.0512. By comparison, most production cars are about six times less aerodynamic.

The Ford Focus ST has a drag coefficient of 0.3, while the Volkswagen Golf comes in at 0.27. The Ecorunner V's body weighs just 9kg, or 38kg including the hydrogen fuel cell. It can achieve an efficiency of 1227.5km per cubic metre of fuel, which is the equivalent of over 3,000km per litre of petrol.

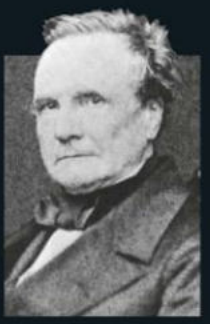
Is the Internet of Things real?

The Internet of Things (also known as 'ubiquitous computing') is a set of smart devices that connect to the internet, making them accessible remotely. Today we have connected heating thermostats, security cameras, motion sensors, lights, doorbells and even toasters. By 2020 it's estimated there will be more than 20 billion connected devices. While this may give us amazing access to information and computing from smart objects all around us, some people warn that our privacy may be reduced because every device could be monitoring us.

Smart meters are just one of the many devices that can be connected to the internet

WHO REALLY INVENTED?

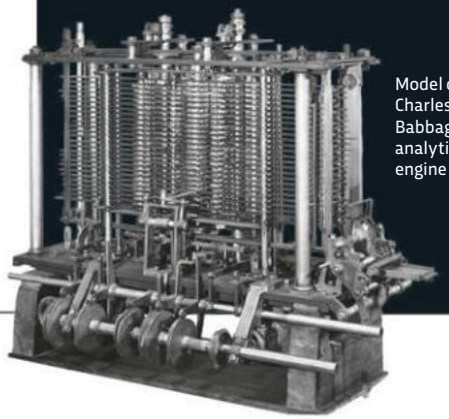
THE COMPUTER



CHARLES BABBAGE

ALAN TURING

Computers are far more than ultra-fast number-crunchers. Crucially, if given a new set of instructions, a computer's processor and memory can – in principle, at least – do anything from word-processing to flying a plane. Credit for being the first to consider building so versatile a device goes to the British mathematician Charles Babbage, who in 1834 began drawing up plans for what he called the 'analytical engine'. His dream was to create a device whose gears, rods and wheels could be arranged – programmed – to perform a myriad of tasks from solving equations to composing music. Only a fragment of it was ever completed. It was 100 years before another British mathematician, Alan Turing, revived the idea of a 'universal machine' and investigated its theoretical powers. During WWII, his code-breaking colleagues at Bletchley Park exploited some of these powers. Their electronic device was called Colossus, and it broke Hitler's most secret ciphers. Historians still argue about who built the first genuine computer, but it's generally agreed that engineers in the US and Britain both succeeded in creating electronic machines embodying Babbage's dream by the late 1940s.



Model of Charles Babbage's analytical engine

The high sides of *Vindskip* act as sails

Is it possible to fool fingerprint readers?

Some will be fooled by a mould of your finger made out of the same gelatin as gummy bears. Others by a fingerprint on a simple piece of sticky tape, or even a simple photocopied image of a fingerprint. Most are not aware if the owner is alive or dead.

IN NUMBERS

222

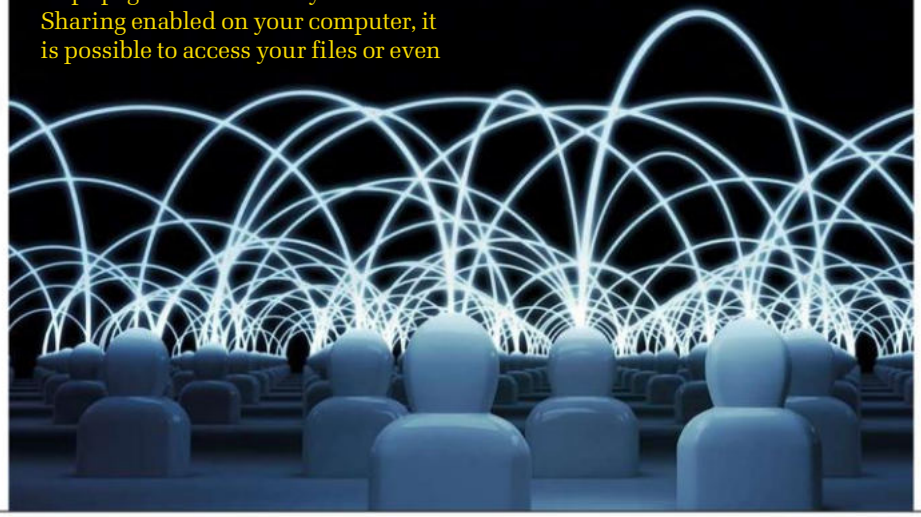
The total distance in millions of miles racked up by self-driving Tesla cars (as of October 2016).

What's the biggest robot in the world?

According to the *Guinness Book Of Records*, the largest walking robot in the world is reported to be Tradinno, a 15m-long dragon robot weighing 11 tons that was used in a German theatre for the play *Drachenstich*. Powered by a two-litre turbo diesel engine, it can breathe flames to a distance of 1.5m. However, in the future, this dragon will be like a toy compared to the 200m-long robot container ship *Vindskip* planned for construction, which would traverse the seas using its giant sides as sails, and its computer brain to keep its course.

ARE PUBLIC WI-FI NETWORKS SAFE?

No Wi-Fi network is completely safe if you have the wrong settings on your phone or computer. When you browse http pages, you are transmitting and receiving unencrypted text; this makes it easy to intercept, making your passwords vulnerable. Only https pages are secure. If you have Sharing enabled on your computer, it is possible to access your files or even remotely log on to your system. For these reasons it's best to keep Sharing switched off, your Firewall turned on, and do not browse sensitive websites on public networks. If you have to do so regularly, you should use a Virtual Private Network (VPN).



PHOTOS: LADE AS, GETTY

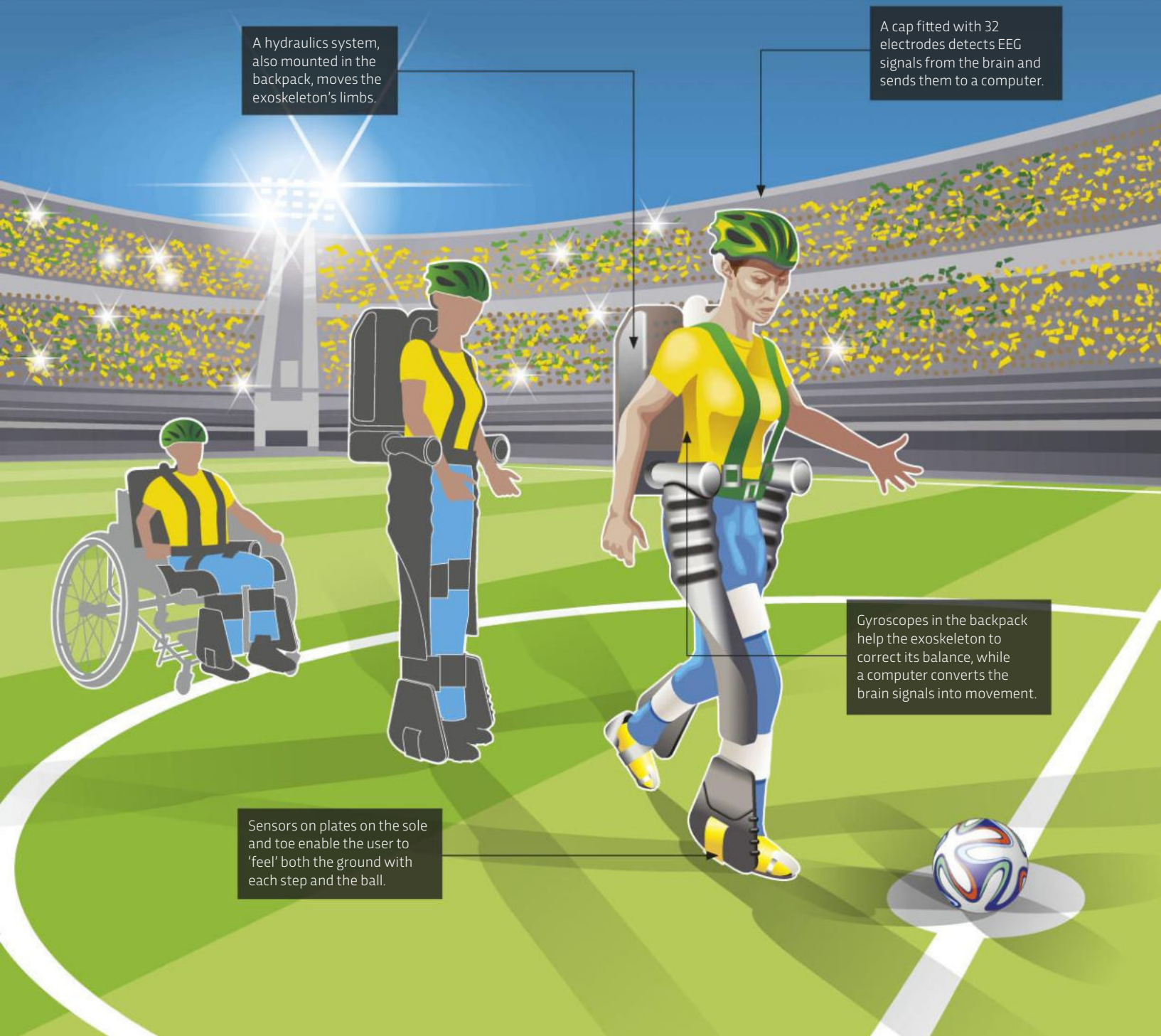
HOW IT WORKS

ROBOT EXOSKELETON

As demonstrated at the 2014 FIFA World Cup, this mind-operated exoskeleton enables sufferers of paraplegia to once again take control of their limbs

The 2014 FIFA World Cup opening ceremony was one of the most spectacular of all time and featured a young paraplegic Brazilian kicking a ball across the pitch at the Corinthians Arena in Sao Paulo. This miraculous act was possible thanks to a mind-controlled robotic exoskeleton, made by the Walk Again Project, a collaboration between universities across different continents.

The operator wears a cap that's linked to a computer in the backpack of the suit. The cap picks up brain signals that are created when the user thinks of walking and a computer then converts this information into electrical commands, which then move hydraulic legs. The whole set-up is stabilised by gyroscopes and powered by a battery that sits in the backpack. When the user kicks the football, they'll be able to actually feel it, thanks to sensors in the feet of the suit that trick the brain into thinking the signals came from the real foot.



Where is all our digital data stored?

If our data is in the cloud, the answer is that we don't know where it is – our files will be spread across data centres anywhere in the world. Because most cloud providers back up the data across multiple sites, your files may well exist simultaneously in more than one place, possibly across different countries, or even across different continents.

Your bits and bytes might, for instance, find their way to a data centre like the massive facility at 350 East Cermak in Chicago, reputedly the biggest such storehouse in the world. It occupies a former printer's/telephone exchange, and houses storage and processing equipment over an area of 100,000m². The servers have a cumulative capacity of 3,000 years' worth of uncompressed video. But that kind of storage is energy-hungry, too. The Chicago facility consumes 100MW, the second-largest electricity bill in the city after O'Hare International Airport.

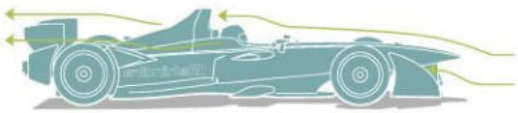
PHOTO: GRAHAM MURDOCH

HOW DOES A

What lies beneath the exterior of these electric race cars may well define the future of high-octane, single-seater racing.

SHAPE

The Formula E car is a little shorter and narrower than an F1 car, while externally they are quite different. Every Formula E car is the same – teams are only allowed to alter the set-up of the standard car. The bodywork optimises aerodynamic efficiency, generating less downforce and has more ground clearance than F1 cars. The driver is cocooned in a 'survival cell', which forms part of the chassis. The cell is made to the same FIA safety standards as F1 cars, complete with a roll hoop, padding inside the cockpit, and front, side and rear crash structures.



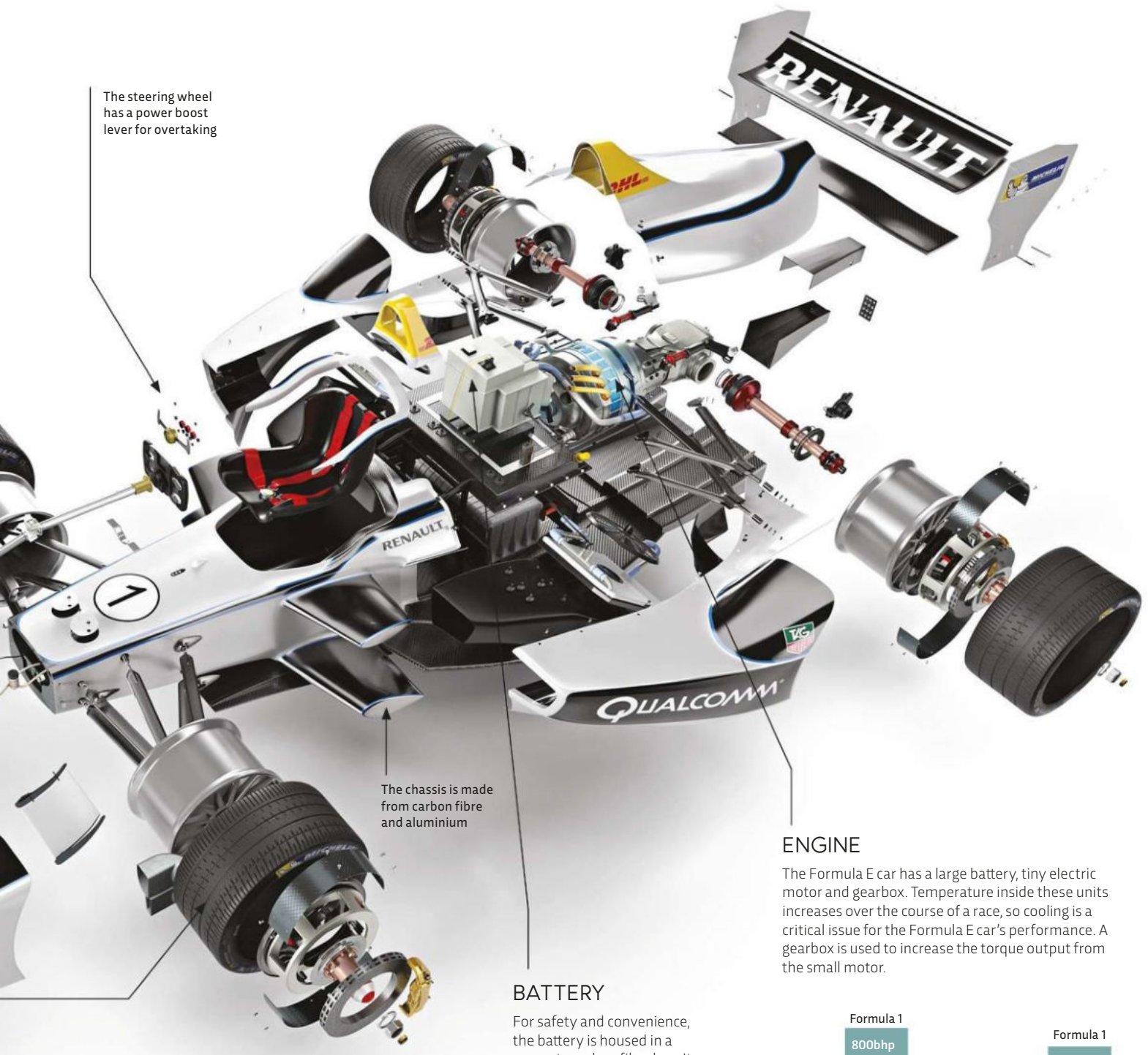
SOUND

The Formula E car is quieter than F1 vehicles, although still makes some noise. The whirr of the electric motor and gears indicates how fast the car is accelerating.

TYRES

The driver gets just five sets of Michelin all-weather grooved 457mm tyres for a one-day event. F1 in comparison, provides the driver with 20 sets for a three-day race weekend: 13 are dry-weather tyres and the rest are wets.

FORMULA E CAR WORK?

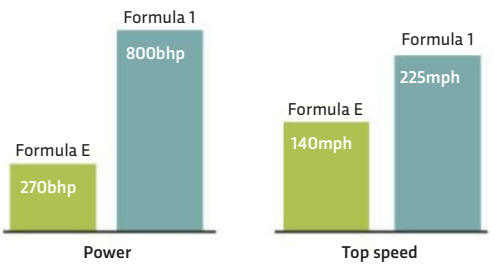


ENGINE

The Formula E car has a large battery, tiny electric motor and gearbox. Temperature inside these units increases over the course of a race, so cooling is a critical issue for the Formula E car's performance. A gearbox is used to increase the torque output from the small motor.

BATTERY

For safety and convenience, the battery is housed in a separate carbon fibre box. Its internals are top secret, but it's made up of large number of lithium ion cells and weighs in at some 300kg. The battery does not have the energy to last a full race, so drivers make a pitstop to transfer into another car.



HOW MANY SETS OF TYRES?

Formula E – 5

Formula 1 – 20

The humanoid robot PETMAN can walk, bend and wave its arms

WHAT'S THE MOST HUMAN-LIKE ROBOT?

Developed by Boston Dynamics, a Massachusetts robotics firm, PETMAN is a humanoid bot that walks, bends and waves its arms. It has been designed to help the US military test chemical protection suits by mimicking the body movements of actual soldiers. PETMAN's gyrations are uncannily realistic, but he's not designed to talk or respond to users.

The iCub scores more highly in that department. Produced through a collaboration of European research institutions, the robot is about the same size as a human toddler and, unlike PETMAN, has a human-like face.

While its features are quite basic, the iCub possesses eyes – indeed, some versions even have eyelids. Possibly because it is so infant-like, the iCub is one of the most convincing human mimics. Its main goal is to aid research into the cognitive development of children.

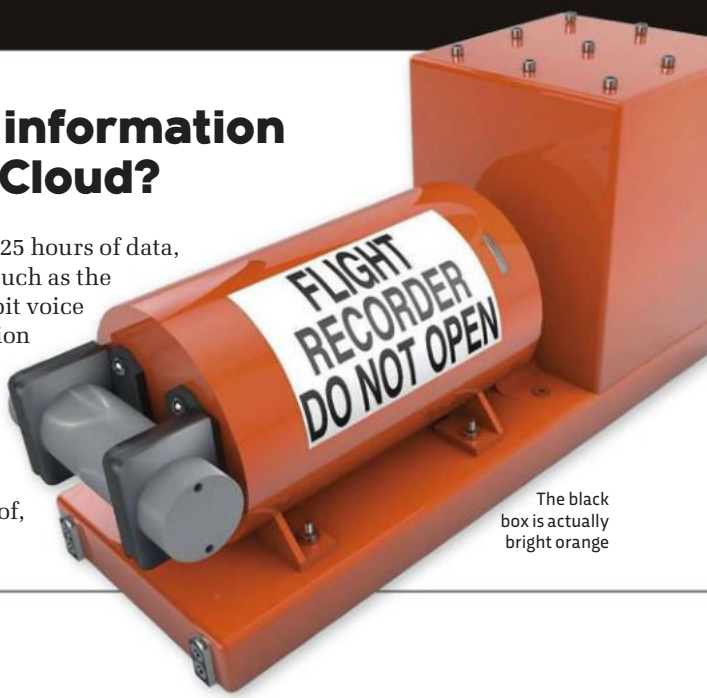
IN NUMBERS

300 hours

of video are uploaded to YouTube every minute.

Could black box information be stored in the Cloud?

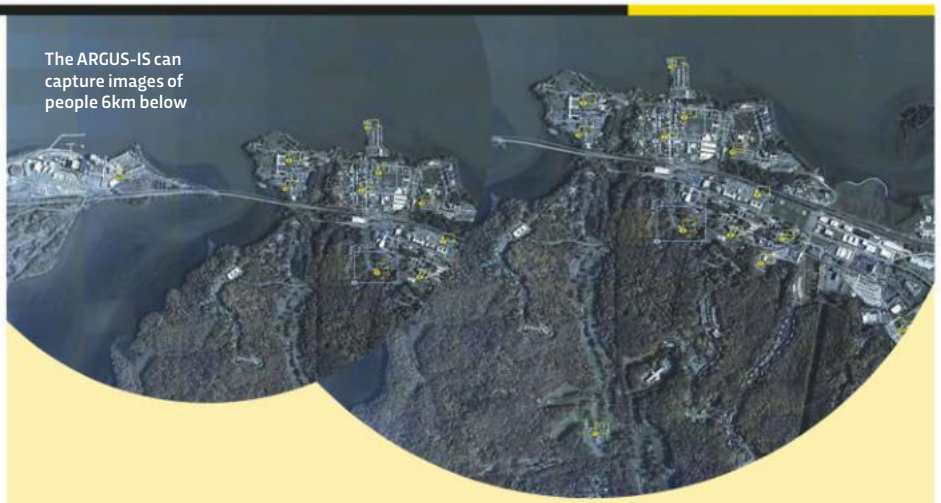
Modern flight recorders store up to 25 hours of data, monitoring at least 88 parameters, such as the time, engine information and cockpit voice recordings. While all this information could be transmitted live to the Cloud, wireless transmissions are susceptible to electrical storm interference, jamming or fraud. So black boxes are self-contained, fireproof, shockproof and waterproof, with their own internal battery.



The black box is actually bright orange

What is the bug bounty programme?

Some hackers love to break into computer systems to see what's 'under the hood'. It's a big problem, so security has to constantly be improved to prevent intrusion. Netscape Communications had a smart idea – they invited hackers to try to break into the early versions of their software, and paid them if any issues were found. This became known as the bug bounty programme, and it is used by many software companies today to help improve their products.



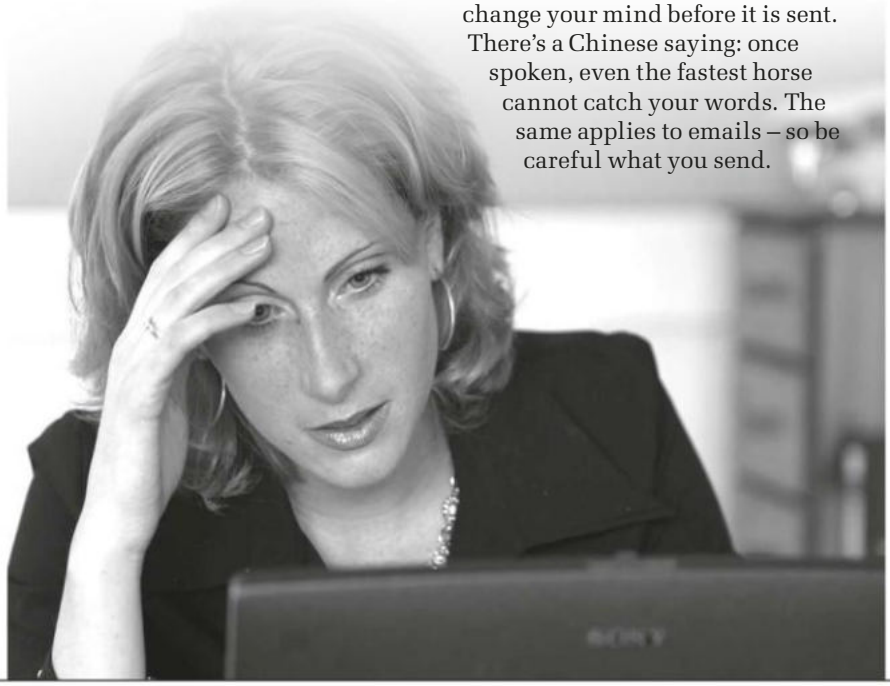
The ARGUS-IS can capture images of people 6km below

What's the highest resolution camera?

A 1.8-gigapixel surveillance camera, built by the US military research agency DARPA. The ARGUS-IS (Autonomous Real-Time Ground Ubiquitous Surveillance Imaging System) straps together a matrix of 368 smartphone cameras into a pod flown on an unmanned aerial vehicle. The results are truly impressive. The camera's resolution is sharp enough to show up individual people 6km (3.7 miles) below, while a single image captures an area over 7km (4.3 miles) across.

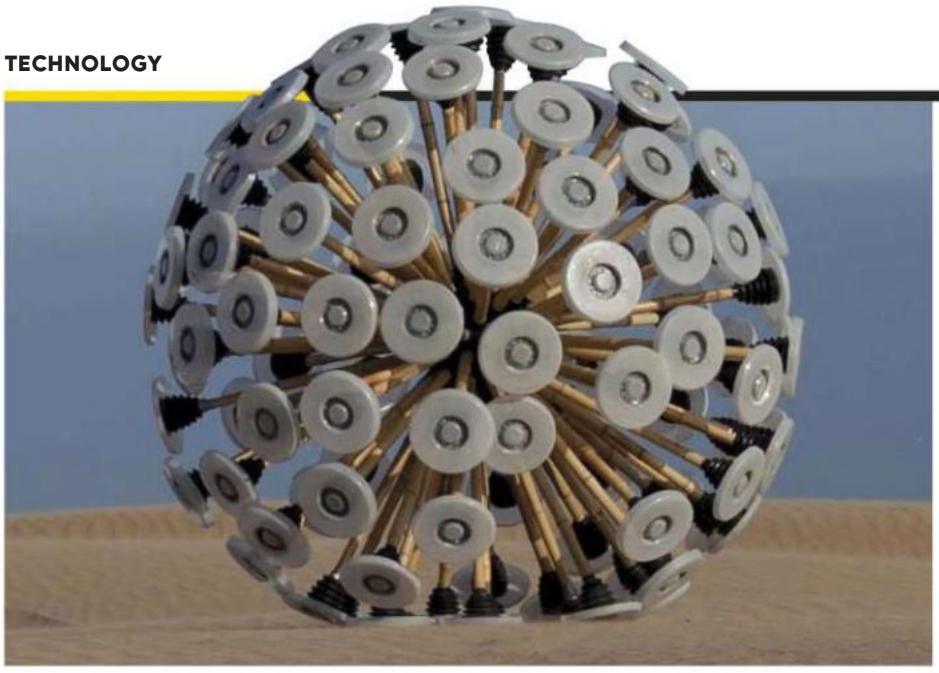
IS IT POSSIBLE TO DELETE A SENT EMAIL?

Sadly not. Once sent, the message is out of your control. Although some email software may have recall or undo functions, these are not doing what you think. Recall will only work if the receiver uses the same email software as you – otherwise the receiver just receives the email followed by a second rather embarrassing email saying 'the sender wishes to recall the previous message'. Undo usually works by delaying the sending of your email for a few seconds, giving you a chance to change your mind before it is sent. There's a Chinese saying: once spoken, even the fastest horse cannot catch your words. The same applies to emails – so be careful what you send.



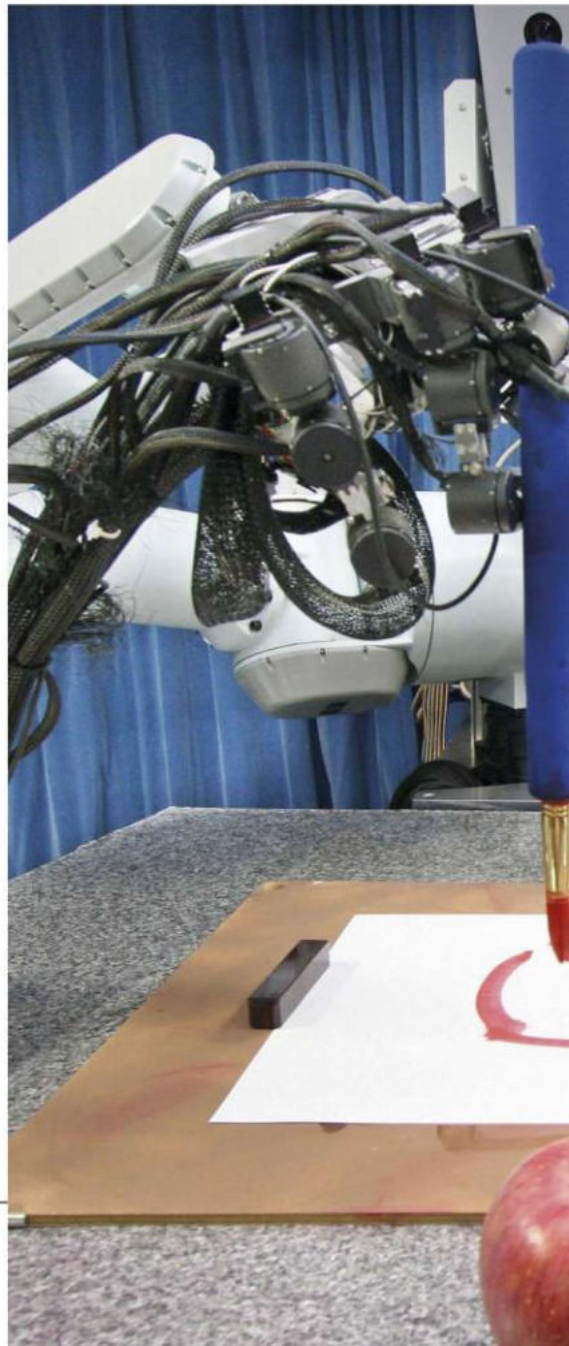
What happens to a person's online data after they die?

Each company that stores the data may have a different policy. If the person was paying a subscription to a website to store their data, then once the subscription expires, the data will probably be deleted. For free sites, anything can happen. For example, Yahoo! refused to hand over emails of a deceased son to his parents, despite being ordered to do so by a court. But Facebook has a policy to change the deceased person's profile into a memorial page, if a family member notifies the company. People can then visit the page to express condolences.



Could drones be used to detect landmines?

It's very tricky to detect mines because they are designed to be hidden from view. An unmanned drone is being developed for this purpose in the UK by Sir Bobby Charlton's charity Find a Better Way. It aims to spot chemicals leaching from mines using its hyperspectral imaging of plant foliage. But most modern devices aim to just safely detonate the landmines. An unusual example is the 'mine kafon' (above). This giant biodegradable ball of bamboo spines is designed to be blown by the wind across a minefield, detonating mines that its spines touch, while its onboard GPS records where it has travelled.



What are supercomputers used for?

The best supercomputers fill rooms, cost millions, and are thousands of times faster than your computer at home. They are usually used for solving complex scientific problems involving lots of maths, such as predicting the weather or climate change, modelling brains or the spread of disease, understanding how the Universe began, or testing the strength of encryption (computer security) methods.

But technology moves quickly. A top-end desktop computer today calculates at the same speed as a supercomputer 10 years ago.

Tianhe-2 is the world's fastest supercomputer

PHOTOS: GETTY, REX

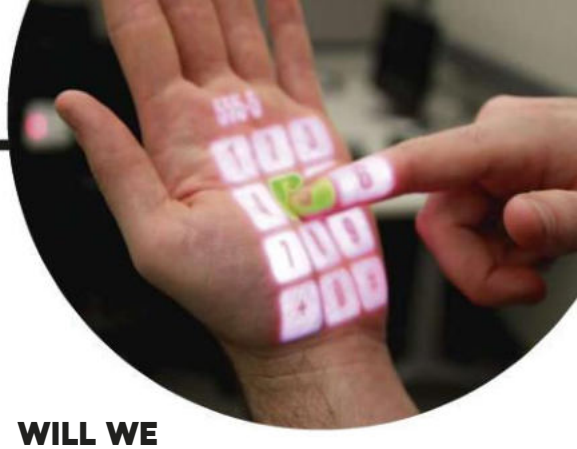
What is the biggest object to be 3D printed?

Architects have actually 3D printed an entire room of a house. They are constructing an Amsterdam Canal House and all 13 rooms will eventually be 3D printed. The 'Kamermaker' (Dutch for 'room maker') printer is 6m tall and is a scaled-up version of the earlier Ultimaker. It will fabricate the entire house from sections up to 3m high and 2m thick. It builds the components layer by layer, squeezing melted plastic at 170°C through the print head.

Branch Technology, a Tennessee start-up, is also 3D printing carbon fibre and plastics to produce objects up to 17m high. The matrix-like forms can be clad with conventional materials like concrete.

DID YOU KNOW?

South Korea has the fastest internet speed in the world – at 26.3 megabits per second.



WILL WE ALWAYS USE KEYBOARDS?

Who knows when, if ever, the QWERTY keyboard won't exist. But many of us already use touch-and-swipe devices like tablets. Microsoft Research and Carnegie Mellon University are working on a system called 'OmniTouch', which combines picoprojectors and movement-tracking software to project virtual keypads on to any surface.

CAN ROBOTS BE CREATIVE?

Yes. Creativity involves combining ideas together in novel ways. In nature, we see amazing creativity arising from evolution, where genes from different parents are uniquely blended. So when we use genetic algorithms, which mimic evolution, computers 'cross over' ideas in novel ways to produce highly creative solutions. Today, computers can compose music, produce art, and design unconventional and efficient solutions to problems.

How can phones get thinner and lighter yet improve their features?

To get better features, you need greater processing power, and to get that you must squeeze more transistors into the phone's chips. A handset today crams in twice as many transistors as one from two or three years ago. It's a feat of miniaturisation where each component is smaller and lighter, allowing you to squeeze more processing out of a slice of silicon. Battery improvements are not quite as dramatic, but lithium-ion devices store ever more charge per kilogram, doubling performance since the 1990s.

Controlling the flow

SPIELBERG

AUSTRIA

Surrounded by the red and white stripes of the Red Bull Ring, Max Verstappen takes his final practice laps before racing in the Austrian Grand Prix on 3 July 2016. In his Red Bull RB12, the Belgian-Dutch driver finished the race in second place, 5.7 seconds behind Lewis Hamilton.

A Formula One car needs to reduce its drag as much as possible, using features like sidepods and spoilers to guide air efficiently around the car. At the same time, the car's underside is carefully designed to direct more air above it than below, creating a higher pressure above which keeps the vehicle glued to the track.

The RB12 has some advanced aerodynamic features, including passages which guide air from below the nose to the upper surface, and front axles which can control the flow of air behind the wheels. This design ensures that air flows along the car in orderly layers, called 'laminar flow', rather than in random turbulent cycles. In Formula One, even the slightest innovations can improve a team's chances on race day.

PHOTO: GETTY


TOTAL
GHeuer

DOES THE SPEED OF LIGHT EVER CHANGE?

Light has long been known to slow down whenever it passes through a medium such as air or glass. Light also interacts with the molecules in its surroundings. But over the years, some theorists have proposed that the speed of light in a vacuum may have been far higher during the Big Bang. While this would solve some of the technical problems concerning the early Universe, there's no compelling evidence that this is the case.

MATHS AND PHYSICS

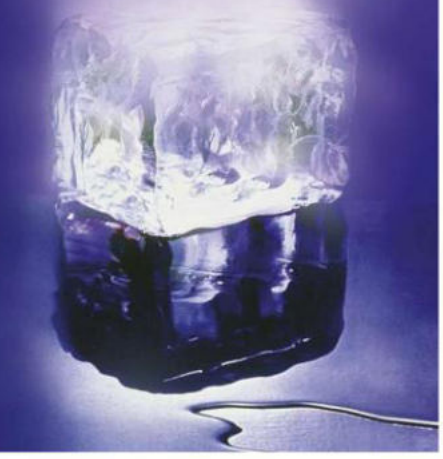
Higgs boson, light speed, time, vacuums, the Big Crunch, gravity, calculus, Large Hadron Collider, hyperspace...

ARE COIN TOSSES REALLY RANDOM?

While a coin toss is regarded as random, it spins in a predictable way. In 2008, a team from the Technical University of Łódź, Poland, analysed the mechanics of a coin tumbling in the air. The study revealed that the coin's behaviour is predictable – until it strikes the floor. At that point, 'chaotic' behaviour sets in, with small differences producing radically different outcomes. This suggests that coin tosses caught in mid-air may have a slight bias, a possibility investigated by Persi Diaconis of Stanford University. He found that caught coins have a slight tendency to face up the same way as when tossed. But the bias is incredibly slight. So the outcome of tossing a coin can indeed be seen as random, whether caught in mid-air or allowed to bounce.

Do all substances have three states of matter?

Far from it: many substances can be found in more than three states of matter, while others have fewer than three. All the chemical elements can be induced to form solids, liquids or gases. But if you superheat a gas, then the electrons get stripped away from the nuclei to form plasma. Stars are made from plasma, so it is the most common state of matter in the Universe. Other more complex materials will decompose before changing states. For example, if you heat wood then it will burn rather than melt. Even if you heated wood in a vacuum, it would break down into simpler substances before changing state.



Not all substances exist in three states of matter

Why do knots weaken a rope?

Anyone who relies on the strength of a rope takes great care to prevent knots forming in it, as they can reduce the breaking strength by more than 50 per cent. The reason is that knots create curved regions of rope whose outer circumference is greater than the inner part. This difference in length creates stress across the rope's width when put under tension, undermining its strength.

PHOTOS: GETTY X2, SCIENCE PHOTO LIBRARY

How fast could you cycle in a vacuum?

When you ride a bike normally, the wind resistance increases with the cube of your speed. At 32km/h, the power needed to overcome the drag accounts for more than 75 per cent of the total cycling effort, rising to over 80 per cent at 40km/h. Recumbent bikes, which have much lower profiles to reduce their wind resistance, can already reach speeds of over 80km/h. If you removed air drag completely, the only friction would be from the tyres and the bearings. Provided you had a high enough gear ratio to allow your legs to pedal at an efficient pace, you could probably reach well over 150km/h.

Will I weigh less if I move to the equator?

As our planet bulges at the equator, its gravitational pull there is lower than in the UK. Better still, the effect of the spin of the Earth at the equator also helps offset the force of gravity. The bad news is that even the combined effect would reduce your weight by less than one per cent – so it's probably easier, all told, just to cut back on the beer and pies.

PHOTOS: GETTY X6, SCIENCE PHOTO LIBRARY

DID YOU KNOW?

The air around a lightning strike is the hottest place on Earth. For a split second, temperatures hit 30,000°C – hotter than the surface of the Sun.

Gravitational waves, as visualised in this artwork, helped us prove that gravity travels at the speed of light

What's the speed of gravity?

According to Einstein's General Relativity, gravity travels at the speed of light. Unlike light, gravity can't simply be switched on and off, and is also extremely weak. Over the years, various attempts have been made to measure the speed using studies of astronomical phenomena, such as the time delay of light as it passes through the huge gravitational field of Jupiter. While the results have been broadly in line with Einstein's prediction, they've lacked the precision needed for compelling evidence. That's now been provided by the celebrated detection of gravitational waves. Analysis of the signals picked up by the two giant LIGO instruments in the US has confirmed that gravity does indeed travel through space at the speed of light.

WHAT WOULD FASTER-THAN-LIGHT (HYPERSPACE) TRAVEL LOOK LIKE?

In the movies, stars stream out into long trails as a spaceship travels through 'hyperspace' or uses its 'warp drive'. Unfortunately, because these concepts are entirely fictional, usually involving alternative universes or extra dimensions, science can say very little about what 'real' hyperspace travel might look like. However, if we regard hyperspace travel as the ability to travel at almost the speed of light, we can categorically dismiss the idea of stars elongating as shown in *Star Wars* and other movies. In fact, as your speed increased, you would see the stars fade and eventually disappear as their light is redshifted into the X-ray part of the spectrum, which is invisible to the human eye. The starlight would be slowly replaced by a diffuse glow, concentrated towards your direction of travel, caused by the cosmic microwave background (the leftover radiation from the Big Bang which fills the entire sky) being redshifted into the visible part of the spectrum.

The films lied to us. Hyperspace travel doesn't look this cool

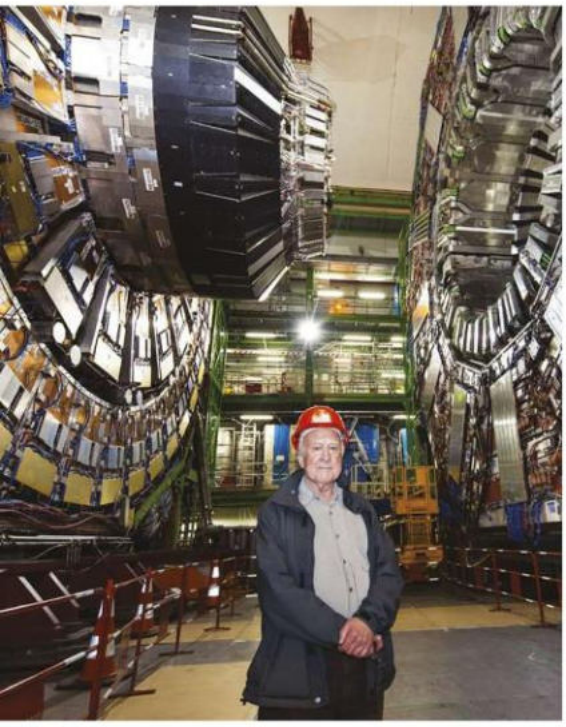
IN NUMBERS

2,520

The smallest number that can be evenly divided by all the numbers between one and 10.

If I throw a ball up vertically on a moving train, will it move away from me?

No – it will land just as if you were standing still. That's because the ball started off in your hand, so was also travelling forward with the speed of the train. Once airborne, it doesn't lose that forward speed, so it keeps up with you and lands in your hand.



Peter Higgs who predicted the existence of the Higgs boson

What has the discovery of the Higgs boson taught us?

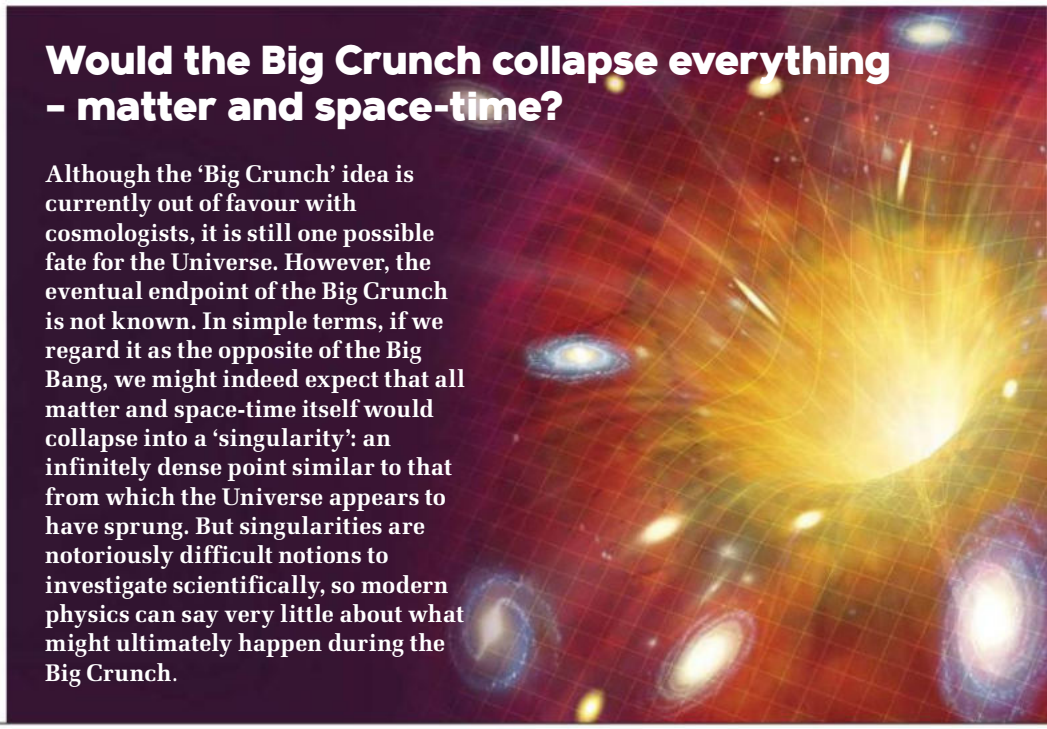
The elementary particle known as the Higgs boson was discovered at the Large Hadron Collider in Geneva in 2012. Most reports of its discovery focused on its role in explaining the origin of mass but, for physicists, the real excitement lay in how it confirmed their beliefs about how the Universe is put together.

For decades they've been searching for a 'theory of everything' to explain all the forces in the Universe, looking for similarities between disparate forces. The problem is that these similarities are sometimes very well hidden. In the 1960s, several theorists, including Peter Higgs (above) at the University of Edinburgh, argued that the apparently radical differences between the weak nuclear force and the electromagnetic force would vanish if a particle with certain properties existed. Later dubbed the Higgs boson, its discovery boosted the confidence of physicists in their strategy for unifying the forces of nature.

Is it possible to create protective force fields?

Deflector shields are featured in spectacular fight scenes in *Star Wars*, but the idea of generating force fields at will can be found in science fiction from the 1930s. But turning it into science fact has proved a major challenge. Research is split into two basic areas: creating fields to protect against blast and radiation, and using them to defend against physical weaponry like shells. Earlier in 2015, the US aerospace company Boeing revealed it has been investigating the possibility of building a force field generator able to protect military vehicles against explosive shockwaves. It's not just the shrapnel from mines and improvised bombs that causes damage, the rapidly expanding gas that they produce can also wreak havoc. The Boeing system is designed to detect the incoming blast and rapidly heat the air near the vehicle, deflecting or absorbing the shockwave's energy. Exactly how this will be done isn't clear – though Boeing thinks that powerful lasers might work. Force fields capable of stopping physical weaponry have also been studied, with the US Army Research Laboratory having looked at the use of powerful electromagnetic fields capable of robbing incoming shells of some of their energy. Again, however, such 'smart armour' has yet to see deployment.

PHOTOS: CERN, GETTY X3, NASA/HUBBLE, SCIENCE PHOTO LIBRARY



Would the Big Crunch collapse everything – matter and space-time?

Although the 'Big Crunch' idea is currently out of favour with cosmologists, it is still one possible fate for the Universe. However, the eventual endpoint of the Big Crunch is not known. In simple terms, if we regard it as the opposite of the Big Bang, we might indeed expect that all matter and space-time itself would collapse into a 'singularity': an infinitely dense point similar to that from which the Universe appears to have sprung. But singularities are notoriously difficult notions to investigate scientifically, so modern physics can say very little about what might ultimately happen during the Big Crunch.

IN NUMBERS

27 kilometres

The circumference of the circular tunnel of the Large Hadron Collider beneath the France-Switzerland border.

DOES TIME SEEM TO GO FASTER WHEN YOU'RE ASLEEP?

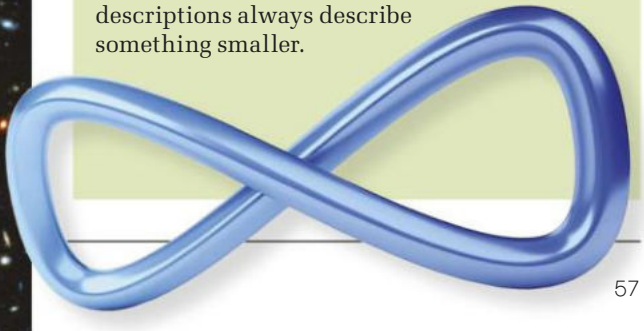
It depends. Most people are good at judging how many hours they've slept. Some can even tell themselves to wake up at a specific time and do so. Time perception can be distorted, though, and experiments show that estimates are generally good, but people tend to overestimate time passed during the early hours of sleep and underestimate during the later hours. Time estimations during dreaming are much more variable and some people claim to have dreamt a whole lifetime in one dream.

Does time exist in space?

Time is a complex subject for physics. Einstein showed that time and space are intimately linked and that the progression of time is relative, not absolute. Although there is nothing in physics that says time must flow in a certain direction, scientists generally agree that time is a very real property of the Universe. Our science is thus based on the assumption that the laws of physics, and the passage of time, exist throughout the Universe.

Are some infinite numbers really bigger than others?

Mathematicians have identified a family of so-called transfinite numbers, which are bigger than the largest finite numbers. The smallest of these is called omega, formed by adding one to each whole number after zero, and continuing forever. Ultimately there is absolute infinity, which is so colossal that attempted descriptions always describe something smaller.



IN NUMBERS

2.5

The global ratio of births to deaths. For every 1,000 people in the world, an average of 7.748 people will die each year and 19.349 will be born.

How do stones skim?

For a pastime dating back at least to the ancient Greeks, it's odd that the science behind skimming stones has only recently attracted scientific interest. After all, there's plenty to ponder. What stops the stones from sinking like, well, stones? And what's the secret to maximising the number of skips? Some answers emerged in 2004, when a team led by Christophe Clanet of the French National Centre for Scientific Research (CNRS) in Marseille published theoretical and experimental results in the journal *Nature*. As every skimmer knows, shape, speed and spin-rate are all important. The team showed, however, that it's the angle to the water that is most important in getting plenty of skips. If the stone hits the water too steeply, it plunges in and sinks. Too shallow an angle causes it to slow down, lose energy and fail to bounce back up off the water. According to the team, the ideal angle is around 20° to the water.

Why is everything in motion?

Everything in the Universe is in motion because forces exist in the Universe. The gravitational force and the electromagnetic force ensure large objects are in motion while the weak and strong nuclear forces ensure the quantum world is constantly in motion. If there were no forces, there would be no motion. The question of why there are forces in the Universe is currently unanswerable by science. They appear to be fundamental and demonstrable facts, but there may not be an ultimate reason for their existence, just as there may not be a root cause for the existence of the Universe itself.

Why do we use a decimal system?

The most obvious answer is that we have 10 fingers, which we can use for counting and displaying the results. This may be why many cultures have adopted the decimal system, but it's not a watertight argument: some Native American tribes decided single hands are enough, resulting in quinary counting systems based on units of five.

Is Jupiter growing, as its gravity pulls in matter?

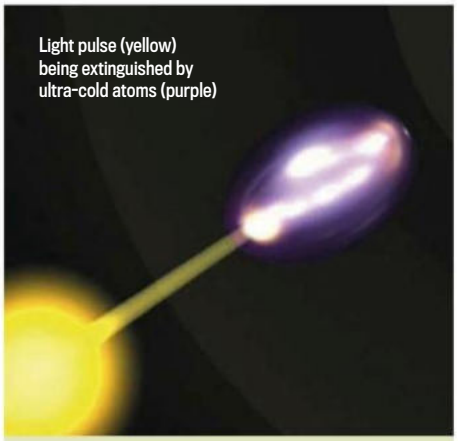
Jupiter's large gravitational field makes it prone to impacts from asteroids, comets and other flotsam. In 1994, the comet Shoemaker-Levy 9 plunged into Jupiter's atmosphere, adding at least one trillion kilograms to the planet's mass. It is estimated that Jupiter's rate of mass increase from impacts or accretion is up to 8,000 times that of Earth's. But this does not mean that Jupiter's mass is increasing. Its atmosphere is so warm that gas molecules are moving fast enough to escape the gravitational pull of the planet. And the solar wind ionises many of the atoms in the Jovian atmosphere. Since these atoms become neutrally charged, they can easily escape Jupiter's magnetic field. This slow but constant loss of mass from Jupiter's atmosphere is actually greater than the gain in mass from collisions so, overall, Jupiter is shrinking not growing in mass.

Can computers keep getting faster?

The laws of physics stop computers getting faster forever. Computers calculate at the tick of an internal clock, so for many years manufacturers made transistors smaller and clocks faster to make them perform more computations per second. However, conventional electronics get too hot if you make them calculate too fast, which is why we no longer see clock speeds increasing much. Instead we now have more and more 'cores' – lots of processors all calculating in parallel – to let them do more work in the same time. Scientists have calculated fundamental limits on maximum speed and storage achievable by computers.

In order to reach those theoretical limits, you may need to use black holes as quantum computers, and they would probably evaporate in a puff of Hawking radiation too quickly to allow them to calculate very much.

PHOTOS: GETTY X5



Light pulse (yellow) being extinguished by ultra-cold atoms (purple)

IS IT POSSIBLE TO TRAP LIGHT?

Perhaps the most spectacular technique was perfected by Prof Lene Hau and colleagues at Harvard University. In 2007 they trapped light inside a cloud of ultra-cold sodium atoms, turned it into a pulse of atoms and then reversed the process – the light reappearing and moving off from its new location.

WHO REALLY DISCOVERED?

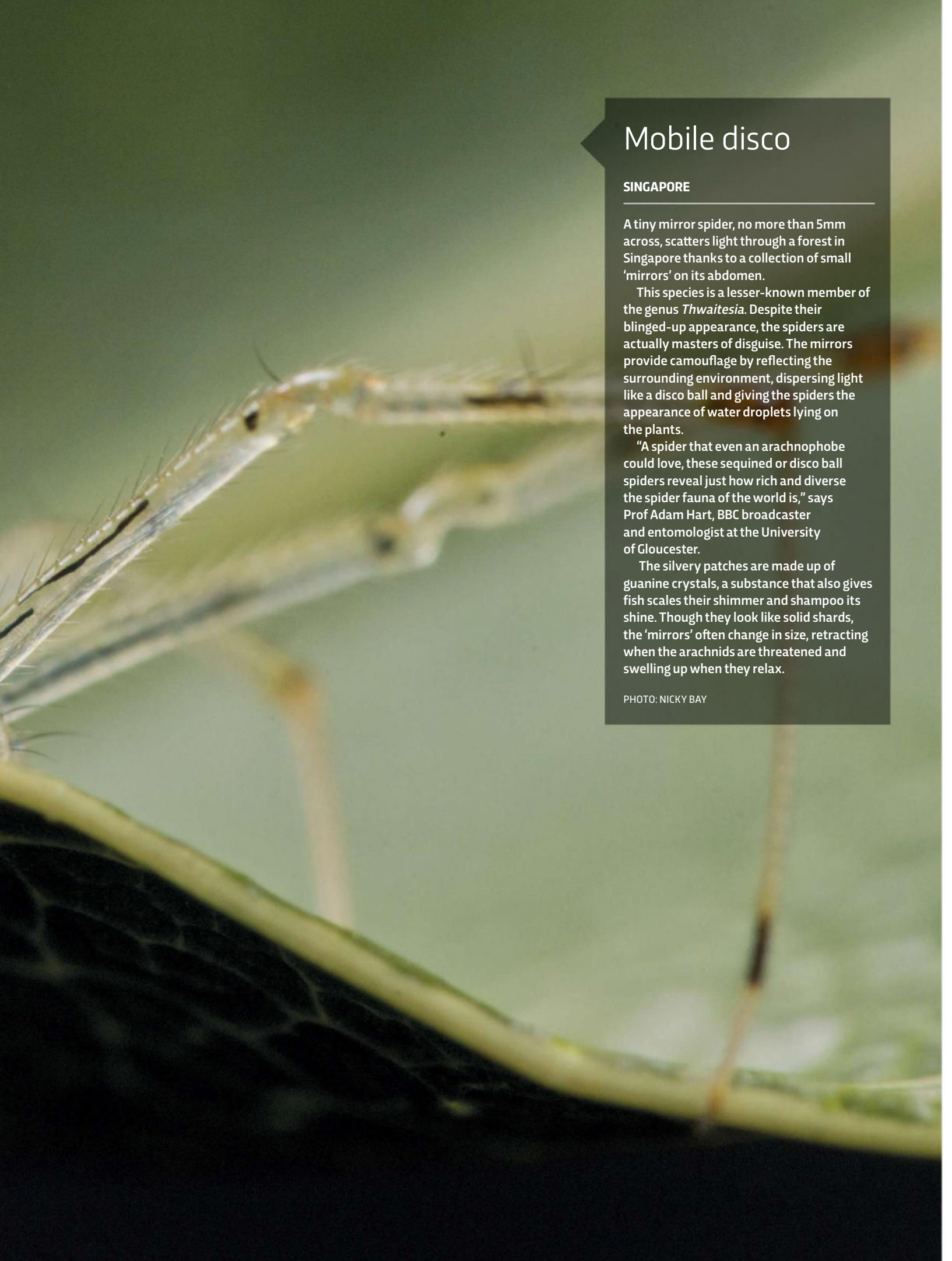
CALCULUS

ISAAC NEWTON

GOTTFRIED LEIBNIZ

Calculus is a powerful mathematical toolbox for dealing with phenomena in a state of flux, from the flow of water to the expansion of the cosmos. As such, a better name for it would be 'fluxions' – a term coined by Isaac Newton, one of the two 17th-Century mathematicians regarded as its inventors, the other being the German Gottfried Leibniz. Not that Newton saw it that way. Having invented it in secret in the 1660s, he was horrified when Leibniz went public with similar methods, having independently discovered them about 10 years later.

Newton launched an unjustified campaign of character assassination against Leibniz, yet could not stop the adoption of his rival's name for the technique (from the Latin for 'counting stone'). It's now known that some basic ideas in calculus had been explored much earlier. For example, Archimedes showed how to work out the area enclosed by curves by dividing it up into tiny strips. This is a trick exploited in integral calculus to work out the total effect of a series of tiny changes. However, none of Leibniz and Newton's predecessors realised the full power of what they were working on.



Mobile disco

SINGAPORE

A tiny mirror spider, no more than 5mm across, scatters light through a forest in Singapore thanks to a collection of small 'mirrors' on its abdomen.

This species is a lesser-known member of the genus *Thwaitesia*. Despite their blinged-up appearance, the spiders are actually masters of disguise. The mirrors provide camouflage by reflecting the surrounding environment, dispersing light like a disco ball and giving the spiders the appearance of water droplets lying on the plants.

"A spider that even an arachnophobe could love, these sequined or disco ball spiders reveal just how rich and diverse the spider fauna of the world is," says Prof Adam Hart, BBC broadcaster and entomologist at the University of Gloucester.

The silvery patches are made up of guanine crystals, a substance that also gives fish scales their shimmer and shampoo its shine. Though they look like solid shards, the 'mirrors' often change in size, retracting when the arachnids are threatened and swelling up when they relax.

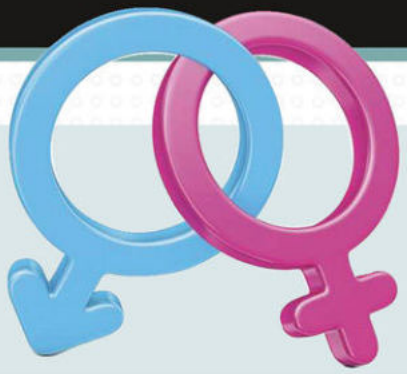
PHOTO: NICKY BAY

WHY DO TIGERS HAVE STRIPES?

When it comes to predatory adaptations, you wouldn't expect a colouration of bright orange with black stripes to be top of the list – in fact, it might not be on the list at all. However, while we typically see tigers in zoos, conspicuous against the green vegetation in their enclosures, their main prey is ungulates, which cannot detect the range of colours that we primates can. To an animal with comparatively poor vision, the cat's bold, contrasting colours are much harder to pick out in the long grass. This method of camouflage is an important predatory adaptation. Whereas some large felines rely on co-operative hunting (such as lions) or bursts of intense speed (such as cheetahs), tigers are semi-solitary and depend on their cryptic appearance to ambush prey.

ANIMALS

Snake venom, cloning mammoths, elephant memory, dinosaurs, sharks, the dodo's relative, coywolves, the world's biggest spiders...



WHY ARE THERE TWO SEXES?

Biologically speaking, the most important difference between the sexes is that females produce eggs that are much larger than the sperm of the male. Large eggs are an advantage because they provide more resources for the developing zygote. But making your eggs large means that you can't produce so many of them, so another valid evolutionary strategy is to make lots of small, cheap sperm. So evolution has gradually driven eggs and sperm in different directions.

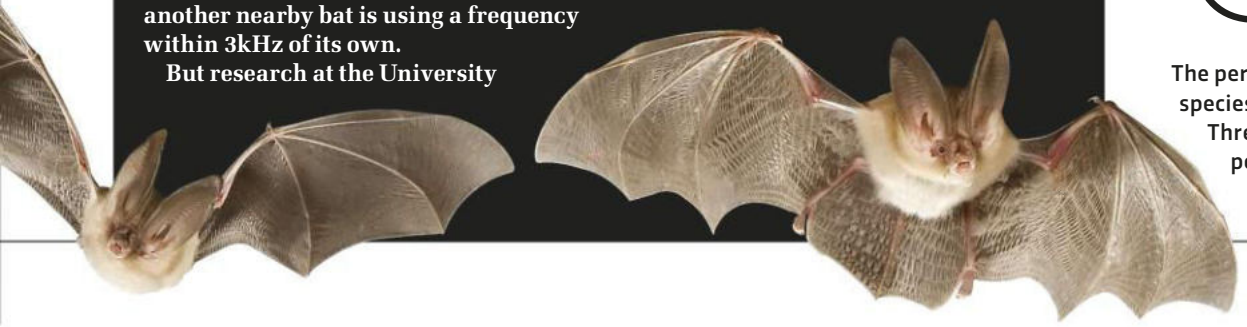
Could we clone a mammoth or a dinosaur?

The oldest DNA fragments recovered are only 800,000 years old, so dinosaur cloning is probably impossible. True cloning also requires an intact, living cell and it has only ever been successful using a host animal of the same species. That rules out mammoth cloning too. What we might be able to do is splice some mammoth genes into the DNA of the Asian elephant, their closest relative. Most of the mammoth genome has already been sequenced from recovered mammoth fragments frozen in the Siberian permafrost. A team at Harvard have managed to insert 14 mammoth genes into an elephant cell in a petri dish. But Asian elephants and mammoths are thought to differ by at least 400 genes, and figuring out exactly which ones are different will take a while. And then that single cell still needs to develop into an embryo and then a baby mammoth. We don't know enough about elephant reproduction to even manage ordinary IVF, and the success rate of implanted cloned cells is so low that it would be impractical and unethical.

Do bats get confused by other bats' 'sonar'?

Some bat species have a wide repertoire of available sound frequencies, so the chances of another bat happening to call on the same frequency within earshot are low. But the Brazilian free-tailed bat will actively switch frequencies if another nearby bat is using a frequency within 3kHz of its own.

But research at the University of Maryland has shown that bats can use the echolocation calls of other bats to navigate by eavesdropping. Big brown bats sometimes stop calling if they are flying close to others, and just listen for the echo from neighbours' calls.



IN NUMBERS

32

The percentage of amphibian species at risk of extinction. Threats are habitat loss, pollution, disease and climate change.

PHOTOS: GETTY, SCIENCE PHOTO LIBRARY, FLPA

What height can a cat survive falling from?

When a cat falls, it reflexively twists in mid-air so that its feet face downwards. One cat survived falling from the 32nd storey of a skyscraper. But landing unscathed is far from guaranteed. A study looked at 132 cats that had fallen an average of 5.5 storeys and survived, and found a third of them would have died without emergency veterinary treatment. Interestingly, injuries were worse in falls less than seven storeys than in higher tumbles. This could be because they reach terminal velocity after falling about seven storeys (21m), which means they stop accelerating. They then relax, allowing better distribution of impact.

IN NUMBERS

100

The approximate number of Scottish wildcats remaining in the wild.

3,300

The grip strength, in Newtons, that a 4kg coconut crab can exert with its claw.

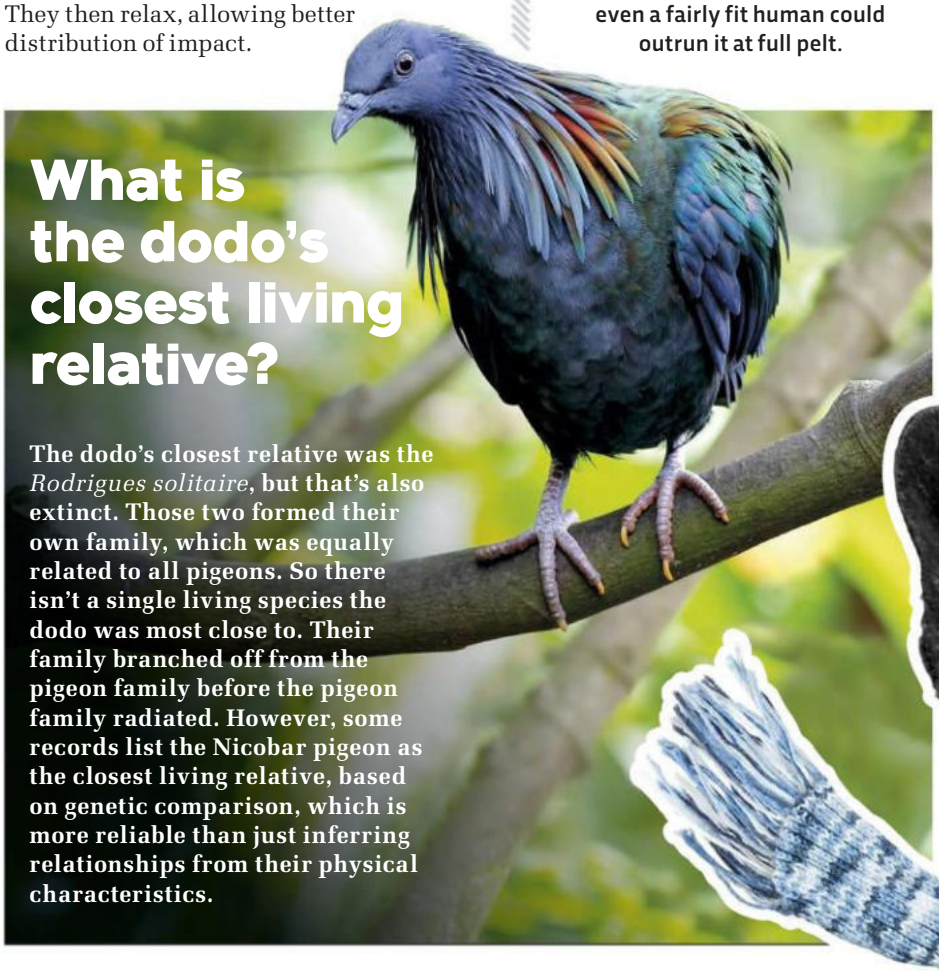
11 km/h

was a *T. rex*'s top speed – even a fairly fit human could outrun it at full pelt.

There's no need for deep-sea angler fish to have good eyesight

Could my pet catch my cold?

The viruses that cause ordinary colds are all quite species specific. Dogs can't catch human colds (or vice versa), but they do have their own version, called canine infectious tracheobronchitis or kennel cough. The influenza virus is much more adaptable though. Bird, pig, horse, dog and human flu have all been shown to jump the species barrier. And bacterial diseases are even more contagious. Cats and dogs can both catch tuberculosis from humans.



What is the dodo's closest living relative?

The dodo's closest relative was the *Rodrigues solitaire*, but that's also extinct. Those two formed their own family, which was equally related to all pigeons. So there isn't a single living species the dodo was most close to. Their family branched off from the pigeon family before the pigeon family radiated. However, some records list the Nicobar pigeon as the closest living relative, based on genetic comparison, which is more reliable than just inferring relationships from their physical characteristics.

PHOTOS: NATUREPL.COM, GETTY X2, ALAMY

CAN FISH SEE IN THE DARK?

It's not strictly 'seeing' but fish have rows of pressure-sensitive organs running down each side of their body called the 'lateral line', which allows them to sense nearby animals from the pressure changes in the water. Sharks and electric eels also have special sense organs that allow them to detect the tiny electric fields generated by other animals.

The greater wax moth can hear frequencies as high as 300kHz

Do elephants really never forget?

Elephants have very large brains for their size and the 'temporal lobe' regions responsible for memory are more developed with a greater number of folds – this results in powerful abilities to 'download' important survival data. The matriarch of a herd (who can live for 60 years) may recognise over 200 individual elephants. During droughts these grandma elephants lead family members to waterholes by recalling detailed maps they've made spanning hundreds of kilometres.

WHICH ANIMAL CAN PERCEIVE THE HIGHEST PITCH OF SOUND?

The greater wax moth, *Galleria mellonella*, can hear ultrasonic frequencies as high as 300kHz (humans can't hear anything above 20kHz). The moth uses this ability to listen out for the ultrasonic calls of bats. The highest frequency bat calls are only 212kHz, so the moth clearly has the edge.

How do sharks smell blood underwater?

When you smell something in the air, it's because scent molecules have dissolved into the wet lining of your nose. Smelling underwater is no different, except that the molecules are already dissolved in the seawater. It's a myth that sharks can smell a single drop of blood from a mile away. Sharks actually have roughly the same sensitivity as other fish and can detect smells at between one part per 25 million and one part per 10 billion, depending on the chemical, and the species of shark. At the top end, that's about one drop of blood in a small swimming pool.

ARE COYWOLVES A NEW SPECIES?

DNA testing shows the 'coywolf' is, in fact, just a variation of a coyote living across eastern Canada and the US. These adaptive 'super predators' carry genes from the coyote, wolf and domestic dog. Throughout the last century, deforestation and farming caused interbreeding between these animals, resulting in the evolution of *Canis latrans* – not a genetically distinct species, yet.

PHOTOS: GETTY X2, NATUREPL.COM, ALAMY, SCIENCE PHOTO LIBRARY X3

Why do dogs bury bones?

Wolves bury food that they can't eat immediately. This keeps it safe from scavengers like crows and the cold ground helps to preserve it. Birds don't have a good sense of smell so they find it harder to locate these buried caches than wolves do. Dogs retain this behaviour and will bury toys or bones – either because they are saving their leftovers, or just because they are bored.

How many UK spiders are actually dangerous?

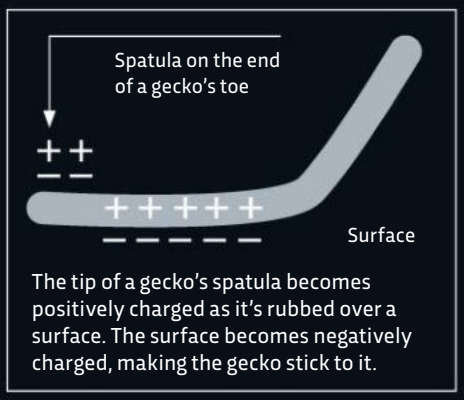
Essentially, none. There are three common spiders in the UK that are capable of biting you: the cellar spider, the woodlouse spider and the false widow spider. Their bites are painful and have been known to cause swelling for a few hours. In 2014 a 60-year-old woman died after being bitten by a false widow spider. However, the cause of death was due to a bacterial infection from the puncture wound, rather than the spider venom itself.

The woodlouse spider has large fangs that it uses to puncture the tough exoskeletons of woodlice

HOW IT WORKS

GECKO ADHESION

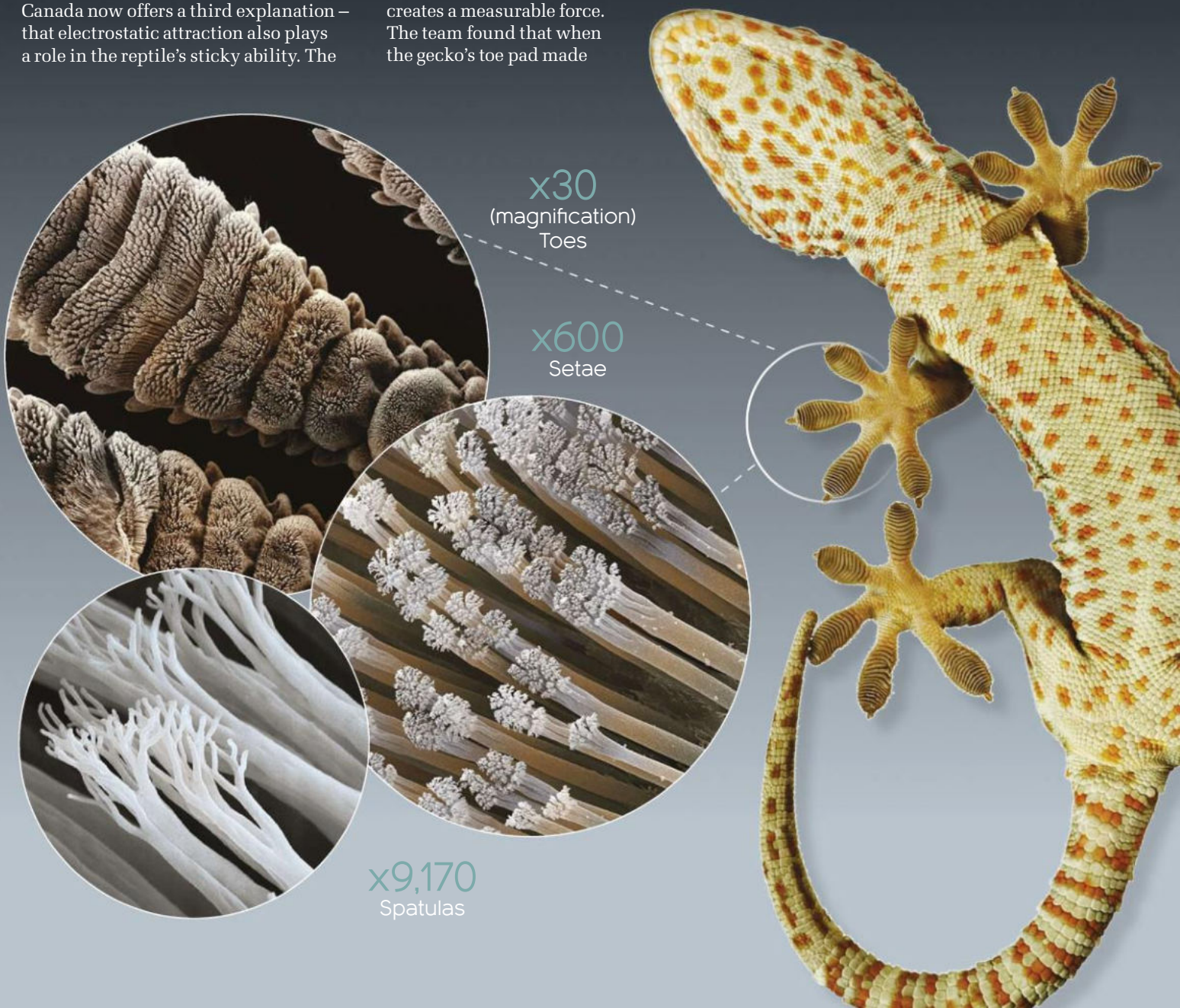
The extraordinary ability of this particular reptile to cling to surfaces has long mystified observers. New research suggests that it may all be down to electrostatic attraction...



The tip of a gecko's spatula becomes positively charged as it's rubbed over a surface. The surface becomes negatively charged, making the gecko stick to it.

Zoologists have long been fascinated by the gecko's Spider-Man-like ability to cling to walls and ceilings. Until recently, geckos were believed to stick to surfaces by making use of two different forces. One is weak van der Waal's forces, formed from the momentary unequal share of electrons between molecules. The other is capillary action, the attractive force that allows kitchen towel to soak up water.

A team at the University of Waterloo in Canada now offers a third explanation – that electrostatic attraction also plays a role in the reptile's sticky ability. The strong, electrostatic force develops from the stable electron exchange between molecules – this is what makes our hair stand on end and stick to balloons. Scientists discovered that a tokay gecko uses this force by gently dragging its feet across a non-sticky surface and measuring the resulting electric charge. Electron exchange takes place where the tiny spatulas at the ends of each hair-like seta on the gecko's toes make contact with the surface of the material. This creates a measurable force. The team found that when the gecko's toe pad made contact with a surface, the pad became positively charged while the surface became negative, creating electrostatic attraction. The strength of the electrostatic charge suggests this force is the most important for the gecko's adhesive ability, yet the other forces are likely to be important when geckos climb wet, slippery surfaces, where electrostatic bonds cannot form.



TOP TEN

BIGGEST SPIDERS

THE WORLD'S LARGEST ARACHNIDS

1. Giant Huntsman
Length: Up to 30cm
Distribution: Caves in Laos. Other huntsman species are found worldwide

2. Goliath Birdeater
Length: Up to 28cm
Distribution: Upland rainforest regions of northern South America

3. Brazilian Giant Tawny Red
Length: Up to 26cm
Distribution: Tropical South America

4. Brazilian Salmon Pink Birdeater
Length: Up to 25cm
Distribution: Atlantic Forest, Brazil

5. Purple Bloom Birdeater
Length: Up to 22cm
Distribution: Moist forest areas of Colombia

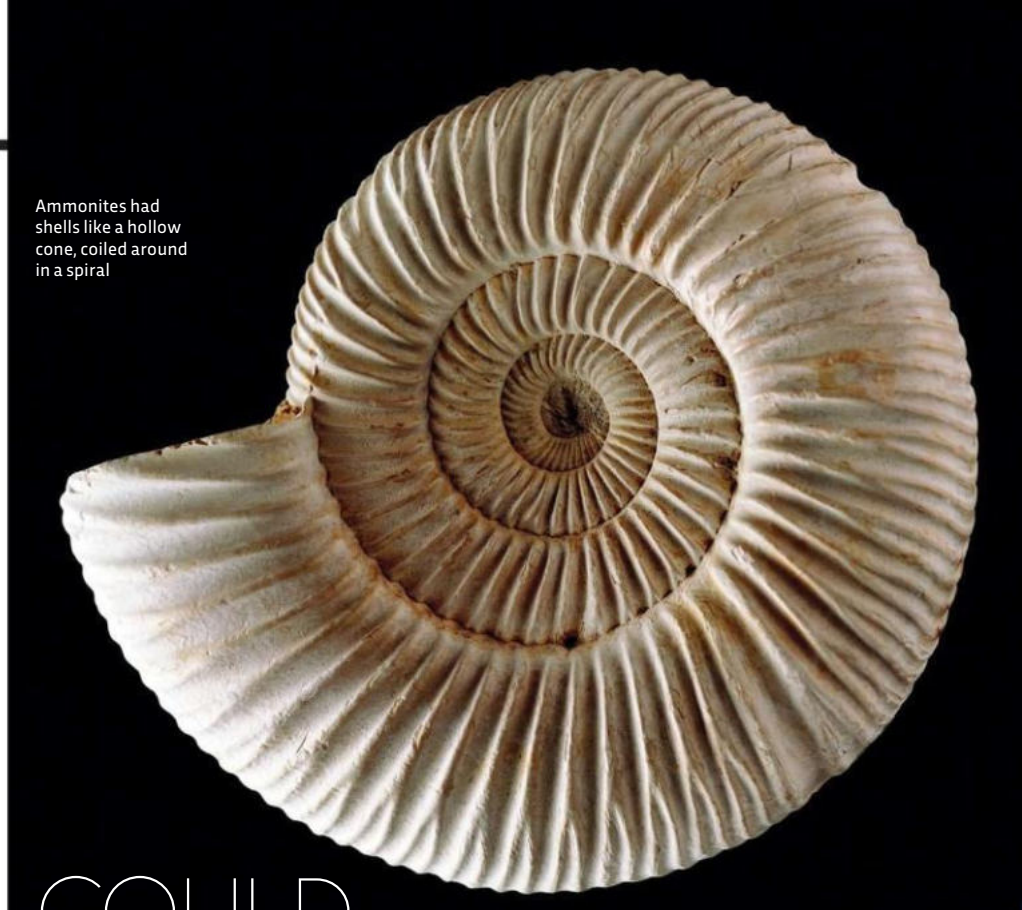
6. Poecilotheria rajaei
Length: Up to 20cm
Distribution: Sri Lanka and parts of India

7. King Baboon Spider
Length: Up to 20cm
Distribution: East Africa, especially Kenya and Tanzania

8. Golden Silk Orb-weavers
Length: Up to 16cm
Distribution: Australia, Asia, Africa and the Americas

9. Brazilian Wandering Spider
Length: Up to 15cm
Distribution: Forests of Central and South America

10. Cerbalus aravensis
Length: Up to 14cm
Distribution: Sand dunes in Israel and Jordan



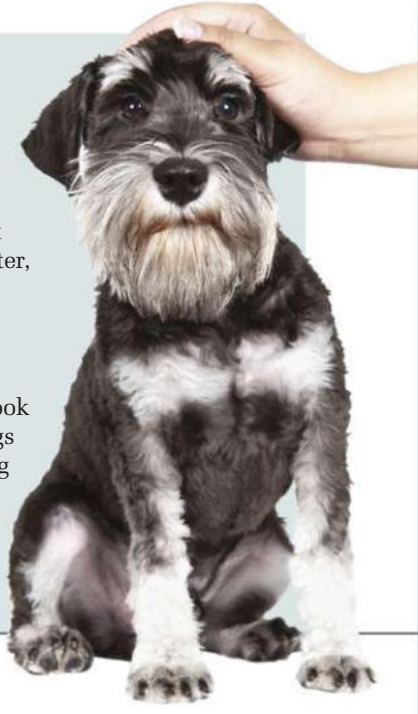
Ammonites had shells like a hollow cone, coiled around in a spiral

COULD AMMONITES SWIM?

Ammonites are a group of extinct marine molluscs and they were able to swim. Their shells are divided into chambers and most of the animal's body sat in the outermost chamber, with just a single tube, called a siphuncle, extending backwards into the older chambers. The siphuncle diffused gas in and out of the shell chambers to adjust the buoyancy so ammonites could float in the mid-ocean. Ammonites are related to modern squid and cuttlefish, and probably swam backwards by squirting water from a siphon. The modern nautilus has a similar shell layout and lifestyle.

Why do dogs and cats enjoy being stroked?

Stroking a cat or a dog causes the hormone oxytocin to be released in both the owner and the animal, which lowers blood pressure and reduces anxiety. But why has such a response evolved? One theory is that animal domestication originally offered a survival advantage to both humans and their pets. Humans selected the friendliest offspring from each litter, so each generation of animals grew more responsive to human contact. Plus, animal-loving early humans took advantage of guard dogs and pest-exterminating cats. Over time, humans and animals evolved to enjoy each other's company.



PHOTOS: SCIENCE PHOTO LIBRARY, MICKEY SAMUNI-BLANK, RANIL NANAYAKKARA, PETRA & WILFRIED, JOSE LUIS BATHELD, ANDREAS KAY, VLADEB, J&T REPTILES, STEVE SMITH, GETTY X2, TJ PETROWSKI

How does snake venom kill so quickly?

Snakes have evolved venoms that contain a cocktail of several hundred different enzymes and proteins. Some block nerve transmission, others interfere with the beating rhythm of the heart, and some break down muscle tissue.

The black mamba injects up to 12 times the lethal human dose in each bite and may bite as many as 12 times in a single attack. This mamba has the fastest-acting venom of any snake, but humans are much larger than its usual prey so it still takes 20 minutes for you to die.

IN NUMBERS

5,407

The number of threatened species on the IUCN Red List that are imperiled by agriculture alone. These species include the cheetah and the African wild dog.

1 million

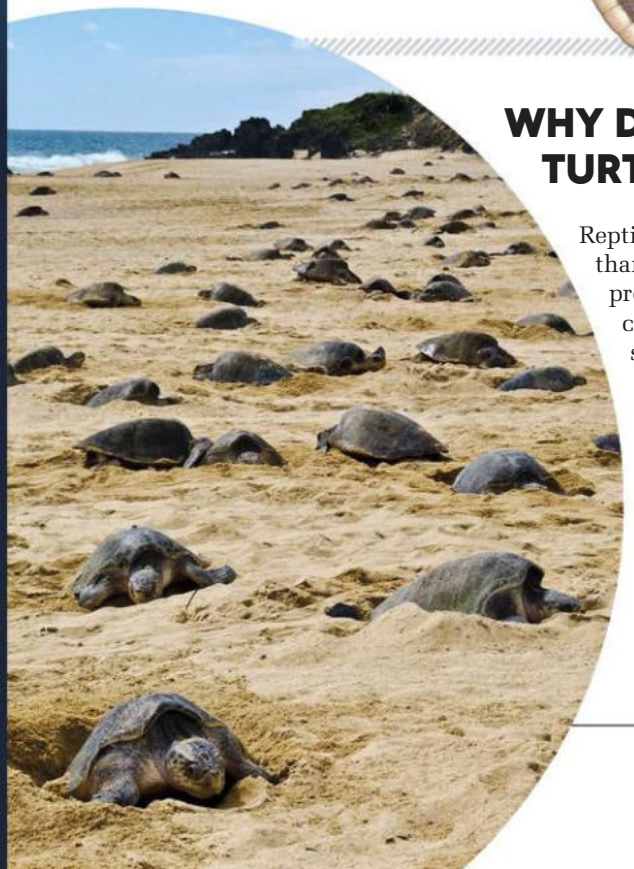
The number of clownfish taken from the wild each year.

Do fish have an immune system?

Most fish have an immune system similar to other animals with backbones. They produce antibodies that detect and bind to substances invading the body, like viruses and bacteria, and instruct white blood cells to destroy them. It's possible to vaccinate a fish against future infections by exposing them to a less virulent strain of a disease-causing microbe. Fish also cover themselves in a layer of sticky mucus that traps microbes and contains antimicrobial chemicals. The more stressed a fish gets, the more goo it makes.

Why do artificial lights attract moths?

Moths don't fly towards the Moon – the idea that moths are trying to navigate by the Moon has been disproved. Exactly why moths fly towards artificial lights still isn't understood. All we know is that artificial lights confuse them in some way.



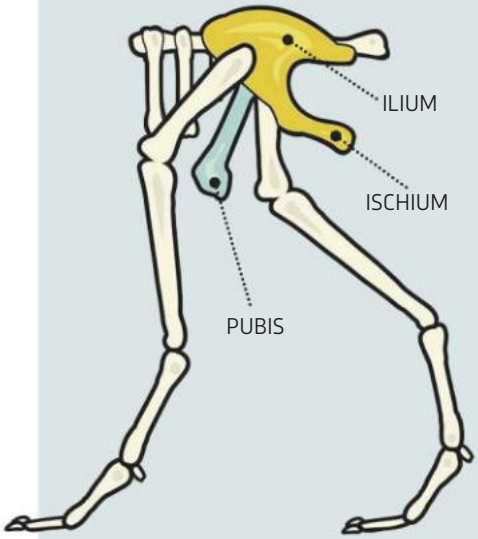
WHY DO SEA TURTLES CRY?

Reptiles have less efficient kidneys than mammals and they can't produce urine with a higher salt concentration than the seawater they drink. To avoid poisoning themselves with salt buildup, sea turtles have a gland in each eye that actively pumps salt ions into their tears. They need to run these glands continuously to maintain the correct balance of salt in their bodies. The tears also help flush sand from their eyes.

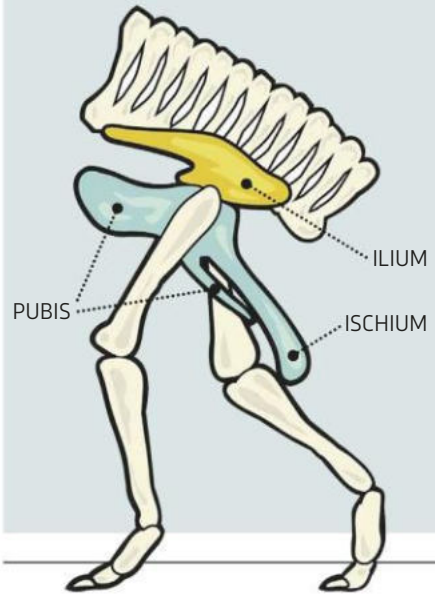
WHAT MAKES A DINOSAUR A DINOSAUR?

It's all to do with the shape of the pelvis. Dinosaurs are divided into two groups: the Saurischia, or 'lizard-hipped' dinosaurs, have a pubis bone that points forward; the Ornithischia ('bird-hipped') have a backwards-pointing pubis. Birds are descended from the Saurischia. Their bird hips evolved independently, much later in time.

SAURISCHIA



ORNITHISCHIA



How do squid survive the extreme pressures of deep water?

A big challenge facing squid in the deep sea is keeping their cells working. Under high pressure, important molecules like proteins in cell membranes and enzymes become squashed and bent out of shape and either work more slowly or not at all. One way squid counteract this is by loading their bodies with trimethylamine oxide or TMAO, which helps large molecules keep their shape. For many deep sea animals, the deeper they live the more TMAO they have in their bodies. TMAO also gives rise to the distinctive fishy smell of many sea creatures – the deeper the species lives, the more it smells.

It was at that point Dave wished he'd taken up a nice desk job instead

How do aquatic snails breathe?

Most species of aquatic snail have a comb-like gill. The oldest groups have two gills but the majority have lost one, to make room inside their spiral shell. As snails moved to the land, they swapped gills for a primitive lung, called the pallial cavity. Some snail groups moved back to freshwater and a few re-evolved external gills. Others stay close to the surface and use a snorkel tube to gulp air now and again. Pond snails mostly breathe air but can flood their pallial cavity and use it as a basic gill when their pond freezes.

Do insects sleep?

Yes. They don't have eyelids, so they don't close their eyes like we do. Cockroaches, however, will fold down their antennae when they sleep, which has the similar purpose of protecting delicate sensory organs. When asleep, insects aren't just resting – sleeping praying mantises will droop downwards and sleeping bees are harder to startle than those that are having a rest.

Laboratory experiments have shown that fruit flies that are forced to stay awake are slower at learning their way round simple mazes than fruit flies that are allowed sufficient sleep.

DO ALL CATS LIKE CATNIP?

Nepetalactone in catnip is a volatile oil, which binds to the sensory receptors in a cat's nose that are normally used to detect sexual pheromones. This creates a 'high' that lasts for about 10 minutes and is perfectly non-addictive. About a quarter of cats lack the gene to enjoy catnip.

Could a dinosaur survive in today's climate conditions?

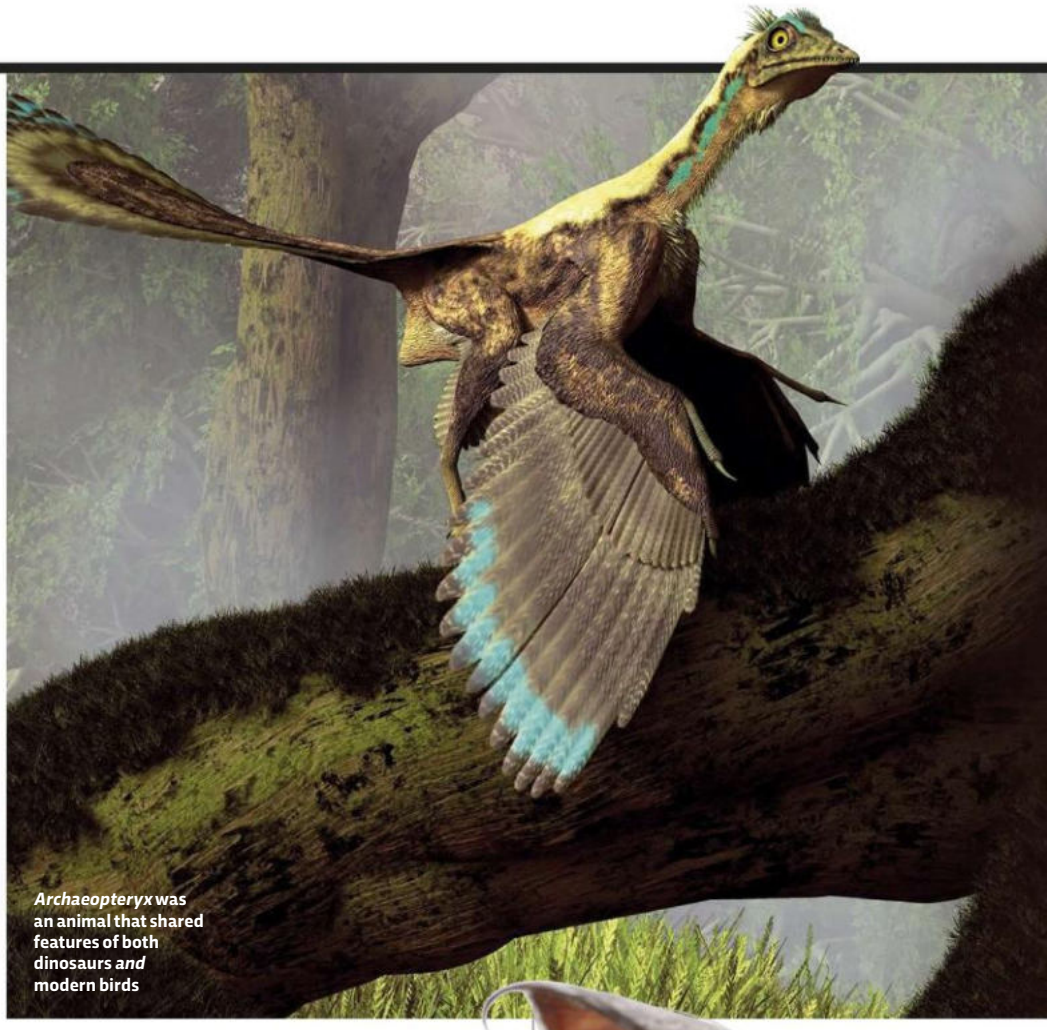
It's doubtful. *T. rex* and *Triceratops* lived in the Cretaceous Period, which ended 66 million years ago. The average global temperature then was about 4°C higher than today. Land dinosaurs would be quite comfortable with the climate of tropical and semi-tropical parts of the world today. That is, until they all died of altitude sickness.

Studies of air bubbles trapped in amber show that the atmosphere of the Cretaceous may have had up to 35 per cent oxygen, compared to today's 21 per cent.

PHOTOS: GETTY X3, PHIL ELLIS

Why do bees die after stinging you?

Honey bee stings have a barbed ratchet mechanism that pulls the stinger into the initial wound. This didn't evolve as a suicide mechanism – honey bees can pull their stings out after stinging other insects. It's meant to drive the stinger in as deep as possible; it just happens that mammal skin is too fibrous to release the sting, so the abdomen is torn open when the bee tries to escape afterwards. Honey bees are the only species to suffer this fate.



Archaeopteryx **was an animal that shared features of both dinosaurs *and* modern birds**

WHICH MAMMAL LIVES LONGEST?

It's probably the bowhead whale – some individuals are thought to have lived beyond 200 years. The evidence comes from both research into the species' eye tissue (ocular amino acids increase over time) and discoveries of ivory spear tips and stone harpoon heads lodged in the blubber of those harvested by Eskimo whalers. Scientists theorise that the species' longevity is down to its low body temperature, which is thought to delay the ageing process. Most whales have a lifespan of 60 to 90 years.

IN NUMBERS

<6

per cent

The proportion of American alligator attacks that are fatal.

17

The number of facial expressions recorded in horses. Dogs manage 16, while we have 27.

Did dinosaurs evolve to be more intelligent?

Dinosaurs evolved into modern birds and some of them are extremely intelligent.

But one reason that birds still aren't as intelligent as humans is that a heavy, energy-hungry brain doesn't mix well with birds' main adaptive advantage – flying.

It's important to realise that intelligence isn't the goal of evolution, nor is it always the best adaptation to the environment. The enormous sauropod dinosaurs lasted on the planet for 100 million years, despite their tiny brains. We've had 'intelligence' for just a few million years, so it's still too early to say whether it is a better strategy for long-term species survival.

Do dogs have visual dreams?

Probably. In 2001, researchers at MIT monitored brain activity in rats as they solved a maze. They found that the animals showed the same brain activity patterns during sleep. The match was so close that the researchers could tell which part of the maze the rat was dreaming about. Cats and mice show similar results, so it is likely that visual dreams are common to all mammals, including dogs.

Why do cats hate water?

Cats groom themselves with constant regular licking, and this stops skin oils from building up on their fur. As a result a cat's coat is fluffier and less waterproof than a dog's, so they get colder and their fur feels heavier if they get wet. But not all cats hate water – the Turkish Van and Bengal are two breeds that like swimming.

Could a slug grow to the size of Jabba the Hutt?

The largest land slug species is the black keel back slug, which grows to 20cm. Slugs don't get much bigger than that because they are cold-blooded, slow-moving, and can't gather enough food to power a larger metabolism. Plus, land slugs have simple lungs and a multi-chambered heart. But, with the right food source, it might be possible for molluscs to evolve to be as big as mammals.

PHOTOS: ALAMY, GETTY X2, SHUTTERSTOCK, RAJA LOCKEY

I'm ready for my close-up

SOUTH BELOIT, ILLINOIS

USA

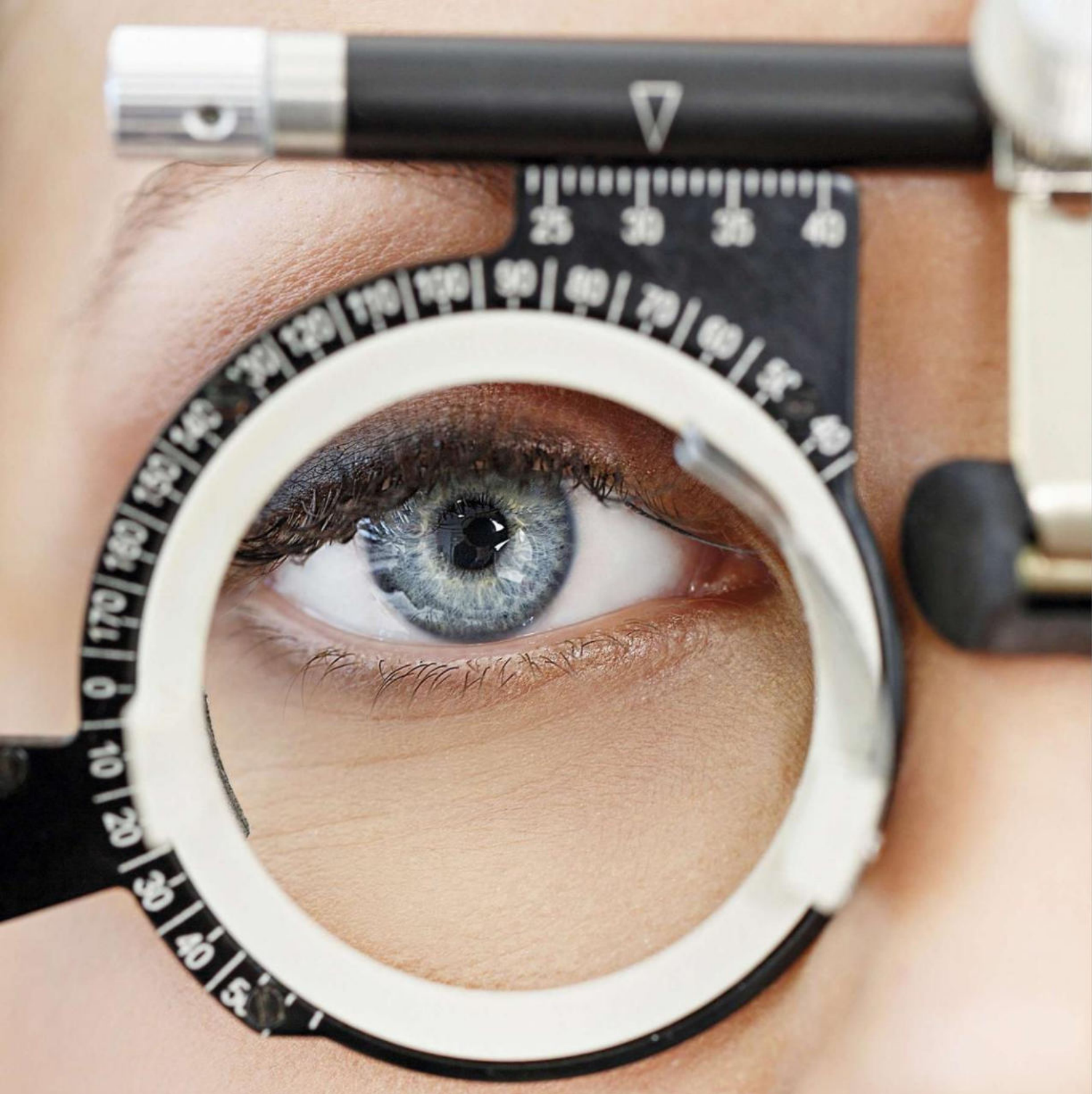
This isn't exactly a smile you'd want to wake up to. These venomous fangs belong to the predatory centipede *Lithobius erythrocephalus*, photographed at 16x magnification. The image was selected as a finalist in the 2016 Nikon Small World photography competition.

Lithobius or 'stone' centipedes are common globally and can be found scuttling around in the damp and dark environments underneath stones and logs.

"Active at night, they are predators of small invertebrates, and the mouthparts of these centipedes are well adapted for taking down their prey," explains BBC presenter and University of Gloucestershire entomologist Adam Hart. "The fangs you can see in the photo are called forcipules. They are not true mouthparts but are modified legs that include a pointed fang and an opening for a venom gland."

Though intimidating up close, the most damage these tiny centipedes can do to a human is a little skin irritation for a few hours.

PHOTO: WALTER PIORKOWSKI/NIKON



WHY HASN'T EVOLUTION SORTED OUT EYE DEFECTS?

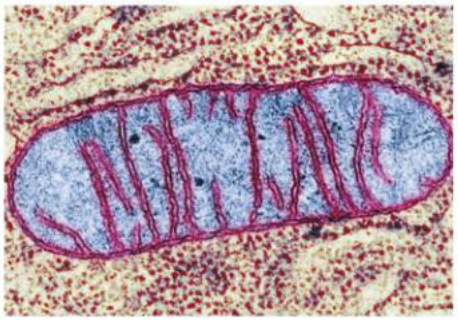
Vision defects like short-sightedness aren't caused by just one single gene. There's some evidence that short-sighted people have a higher than average IQ, which may be because the same genes affect the eyes and brain. Vision defects also often have environmental causes. Short-sightedness is more common in people who do a lot of close-up work, have saturated fat in their diet and sleep with a light on. These are all relatively new in the history of human evolution.

GENETICS & EVOLUTION

The genetics of twins, intelligence and gender.
The evolution of humour, beards, big brains and warm blood...

WHY DO MITOCHONDRIA HAVE THEIR OWN GENOME?

Mitochondria are tiny chemical factories inside our cells. They have several roles, including extracting and storing energy from digested food. But they also have their own DNA, hinting at a once-independent existence. It's thought that this reflects their origin as bacteria, which formed a symbiotic relationship with organisms about 2.4 billion years ago.



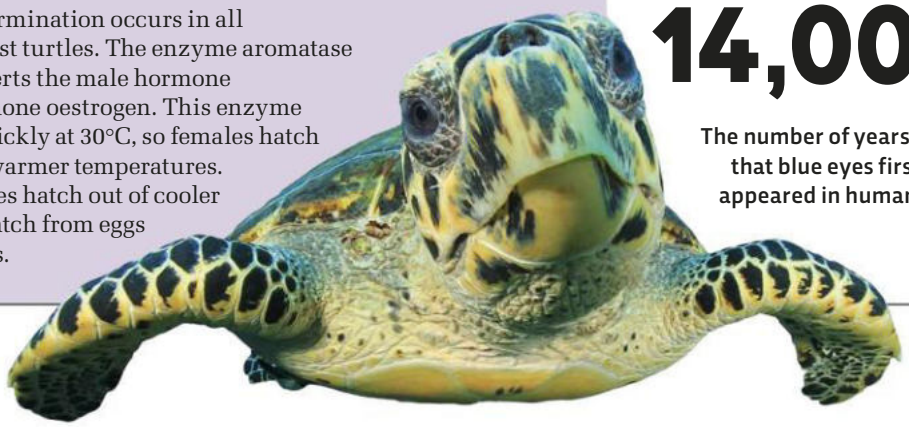
Mitochondrial DNA is inherited from your mother

Do identical twins think alike?

The genes we inherit from our parents influence our psychological characteristics – things like our intelligence and memory ability – and our chances of developing conditions that affect the way we think, such as autism and schizophrenia. In that sense, identical twins – who share all the same genes – do think more alike than unrelated people or even non-identical twins and other siblings. Brain-imaging research has shown that during mental tasks, such as memorising numbers, the patterns of brain activity are more similar among identical twins than non-identical twins.

How does temperature affect gender in some species?

Temperature-dependent sex determination occurs in all crocodiles and alligators, and most turtles. The enzyme aromatase seems to be important, as it converts the male hormone testosterone into the female hormone oestrogen. This enzyme reacts slowly at 25°C but more quickly at 30°C, so females hatch out of eggs that are incubated at warmer temperatures. Except in some species the females hatch out of cooler eggs, and in others, males only hatch from eggs in a middle range of temperatures.



IN NUMBERS

14,000

The number of years ago that blue eyes first appeared in humans.

PHOTOS: GETTY X2, SCIENCE PHOTO LIBRARY

TOP TEN

DEADLIEST VIRUSES

BY HUMAN FATALITIES BY YEAR

1. HIV – human
Deaths per year: 1.6 million
Spreads: via infected bodily fluids
Symptoms: weight loss, respiratory infections, rashes

2. Hepatitis B
Deaths per year: 600,000
Spreads: via infected blood
Symptoms: yellow eyes, dark urine, vomiting, abdominal pain

=3. Influenza
Deaths per year: 500,000
Spreads: via coughs and sneezes; also via bird droppings, blood and saliva
Symptoms: fever, aches, fatigue

=3. Hepatitis C
Deaths per year: 500,000
Spreads: through blood contact with an infected person
Symptoms: fever, stomach pain, itchy skin, liver disease

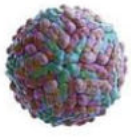
5. Rotavirus
Deaths per year: 450,000
Spreads: through ingestion of contaminated stool
Symptoms: vomiting, diarrhoea, dehydration, fever

6. Measles
Deaths per year: 122,000
Spreads: through direct contact with an infected person
Symptoms: fever, white spots/red blotches, vomiting, diarrhoea

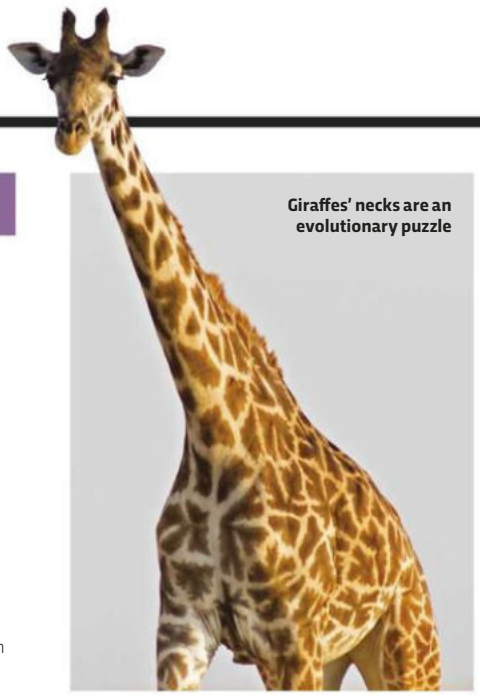
7. Hantavirus
Deaths per year: 70,000
Spreads: via rodent droppings
Symptoms: facial flushing, hypotension, respiratory and renal problems

8. Rabies
Deaths per year: 55,000
Spreads: via animal bites
Symptoms: acute pain, violent movements, depression, mania, inability to swallow water, coma

9. Yellow fever
Deaths per year: 30,000
Spreads: via mosquito bites
Symptoms: fever, bleeding into skin, slow heart, jaundice, coma



10. Dengue
Deaths per year: 25,000
Spreads: via mosquito bites
Symptoms: fever, muscle pain, rash, circulatory failure, shock



Giraffes' necks are an evolutionary puzzle

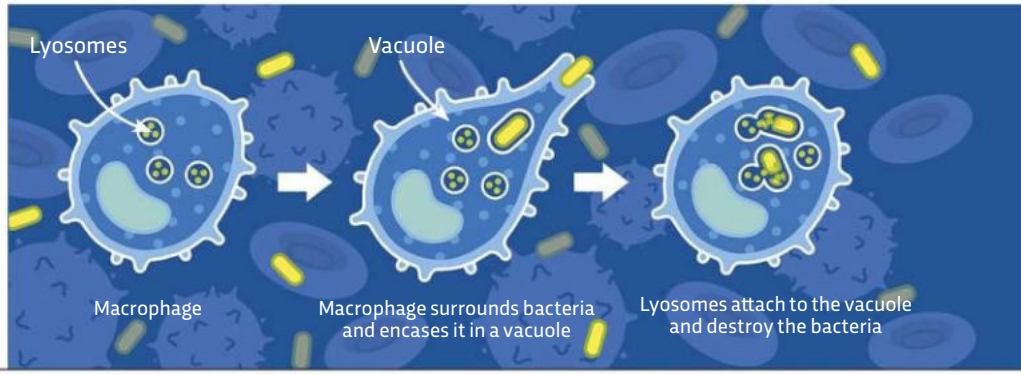
Aren't epigenetic effects evidence for Lamarckism?

No. Epigenetics is when genes alter their activity in response to external factors such as diet, exercise and chemical exposure. The sequence of letters in the DNA doesn't change, but the DNA molecule acquires other chemical changes that can be passed on to your offspring. These inherited traits last for two or three generations. Lamarckism says the giraffe got its long neck because parents stretched their own necks slightly during their lifetimes and passed that increase on to their children, and so on. That's quite different from the Darwinian view that each generation has a certain amount of natural variation, and that giraffes with longer necks have more offspring. Epigenetics is an important influence on evolution, but it doesn't drive long-term species change.

Is the rate of human evolution increasing with population growth?

Larger populations create more chances for genetic mutations to occur, meaning more variations for natural selection to either favour or weed out. But in big populations, it takes longer for changes to spread. The fastest rate of evolution occurs when a population is split into isolated subgroups that can't interbreed due to geographic or cultural barriers. Travel has broken down many barriers, so our genes get blended together instead of splitting into subspecies. We are actually evolving around 100 times faster than at any other period in our history, but 'modern' for an evolutionary biologist means the last 5,000 years. But it is too soon to tell how our evolution has been affected by the population explosion of the last few centuries.

PHOTOS: RAJA LOCKEY, GETTY X9, ALAMY X4



WHY DO BABIES LEARN LANGUAGE SO EASILY?

Recent research on babies' hearing may throw light on an old controversy – are our brains like blank slates, able to use any sounds equally easily and develop almost any kind of language? Or do we have a 'language instinct', with brains that have an innate capacity to learn language? Newborn Italian babies were played different sounds, some of which, like 'bl' are common in many languages, while others, like 'lb', are very rare. Using near-infrared spectroscopy, which can detect brain function without needing a scanner, they found that the babies' brains reacted far more strongly to sounds such as 'blif' than to 'lbif'. The babies were too young to have learned any words yet or even to begin babbling. So it seems as if their brains were ready prepared for the sounds of language.

Why do you take longer to heal as you age?

Wound healing is a complex process involving the immune system. Unfortunately, some parts of the immune system deteriorate as we get older.

For example, ageing affects the function of white blood cells called macrophages (big eaters). These cells play key immune roles, especially in wound repair. They chomp their way through debris at the wound site, and help to promote tissue reconstruction by producing a growth factor that boosts the cells that make connective tissue and collagen. Meanwhile, in broken bones, macrophages secrete chemicals that attract stem cells to the injured site.

Ageing appears to alter these important interactions between macrophages and stem cells.

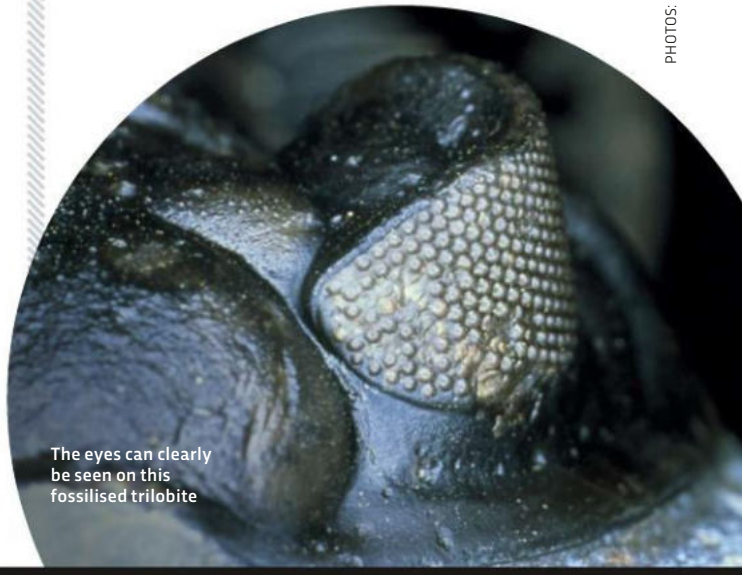
Why did humans evolve a sense of humour?

A recent theory holds that humour evolved because it encourages us to perform the arduous task of fact-checking our assumptions about other people's intentions and perspectives. By this account, mirth is the reward we get when we debunk one of our presumptions and see things suddenly in a new light – jokes are 'super-normal stimuli' that exploit this system. Once it evolved, humour became a social signal – we assume funny people are intelligent and friendly, and men and women alike prefer witty partners. On average, however, men tend to be more concerned that would-be partners will find their jokes funny, whereas women are more attracted to people who make them laugh.

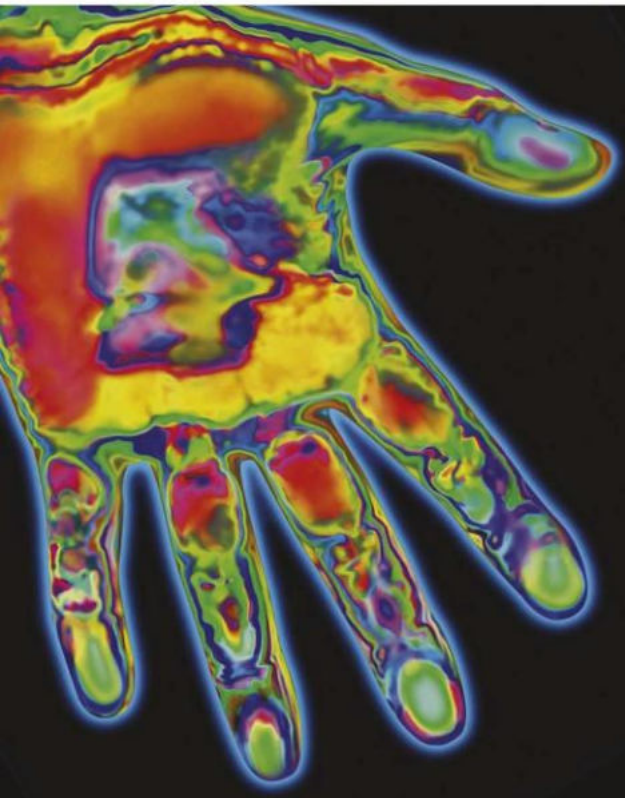
WHAT EVOLVED FIRST: EYES OR EARS?

Eyes, by at least 40 million years. The only invertebrates with ears are land arthropods and they didn't emerge until about 480 million years ago. Older invertebrates had antennae that would have been able to sense vibrations in the water, but that's not quite the same thing as hearing. Trilobites already had complex compound eyes 521 million years ago, and simple eyespots without a lens probably date back to 570 million years ago, when the first multicellular animals appeared.

PHOTOS: GETTY X3, SCIENCE PHOTO LIBRARY, ALAMY



The eyes can clearly be seen on this fossilised trilobite

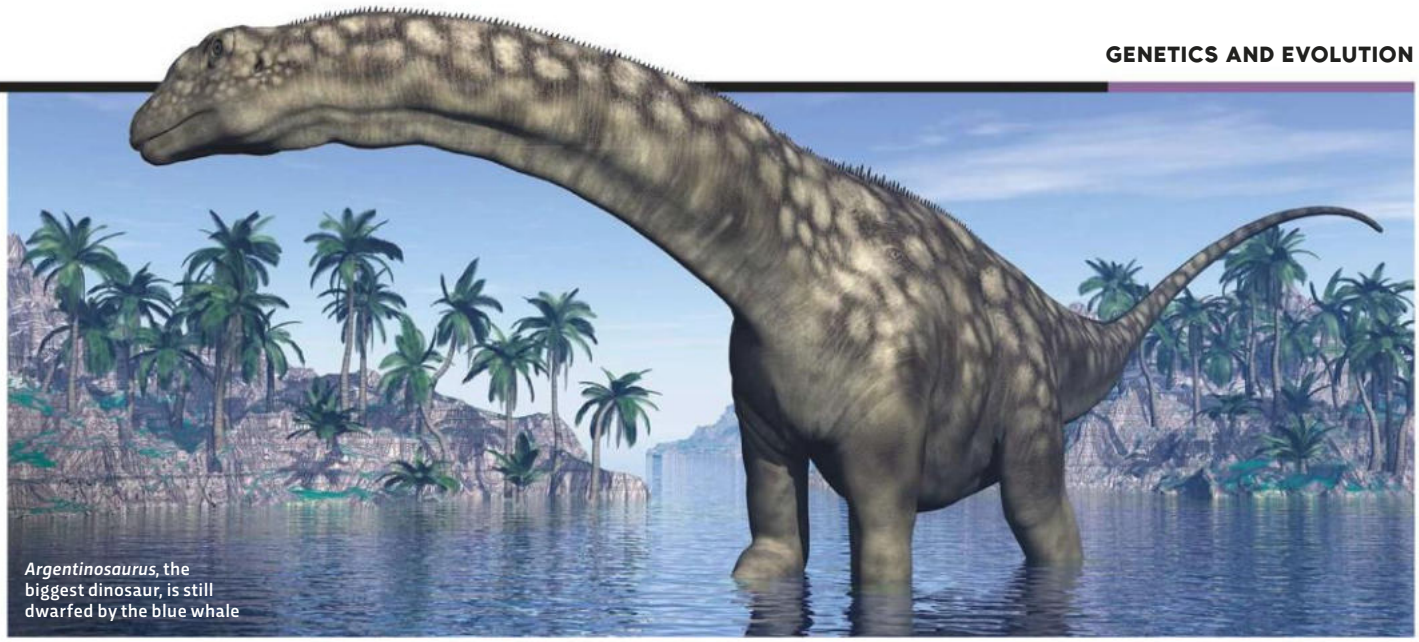


WHY DID WE EVOLVE WARM BLOOD?

Being warm blooded means that your body is maintained at a fixed temperature, regardless of how cold your surroundings are. The term for this is homeothermy. Less than one per cent of animals are homeothermic – it's basically confined to mammals and birds.

Homeothermic animals burn more fuel and need about 10 times as much food. However, chemical reactions generally happen faster at warmer temperatures and a warm body can work at the same activity level even in cold environments, such as at night, underground or in winter. Insects often can't fly when it is too cold because their flight muscles can't contract fast enough and many reptiles have to bask in the sun for several hours each morning to warm up. A regulated body temperature also allows you to evolve enzymes that are tuned to work efficiently within a precise temperature range. The downside of this is that hypothermia or heatstroke are enough to render our enzymes inactive and kill us.

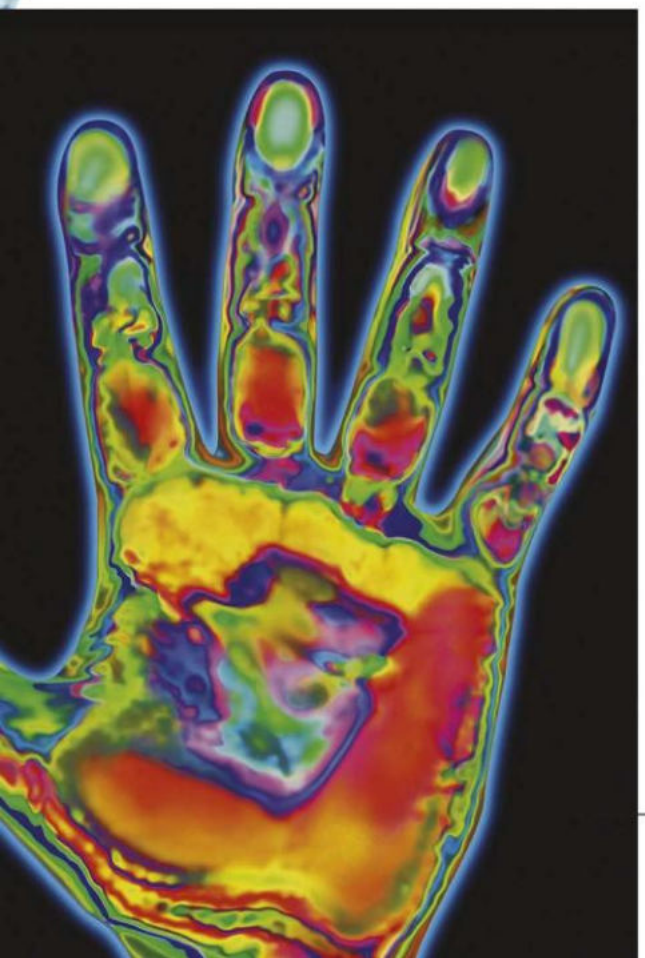
Another possibility is that homeothermy may have evolved as a strategy for fighting infection. A 2010 study found that a body temperature of 36.7°C was enough to protect against most fungal infections. Mammals and birds rarely get fungal diseases, but they are a problem for fish.



Argentinosaurus, the biggest dinosaur, is still dwarfed by the blue whale

How big could an animal get?

Based purely on the physical strength of bone and muscle, it has been calculated that land animals of at least 100 tonnes and possibly as much as 1,000 tonnes ought to be able to support their own weight and move around. That's much bigger than even the largest dinosaur (*Argentinosaurus* probably weighed 80 tonnes at most), but that's because other limits cut in first. The largest animal to have ever lived is the blue whale. At 180 tonnes, it already has to eat 1.5 million calories a day. Blue whales eat krill, which is one of the most abundant food sources in the ocean. Even so, about half the global population of krill is eaten every year by whales, seals and fish. A single freak blue whale that was double the normal size could still probably find enough food. But if all blue whales grew this big, the population would need to be smaller and they would reproduce more slowly than they do now, making them more vulnerable to extinction.



IN NUMBERS

48 million

is the age in years of a 12.5cm-long fossilised foetus being studied in Germany. The specimen is thought to be an early horse-like species.

7 million

The amount of egg cells present in a 20-week-old female foetus, decreasing to about a million at birth.

Thank your parents for your high IQ

Are academic traits genetic?

Yes. Evidence shows high heritability of IQ, and IQ scores are closely correlated with academic performance, as well as occupation, health and income. The most recent conclusion from numerous studies, comparing the abilities of identical and non-identical twins reared together or separately, is that the heritability of intelligence rises from about 20 per cent in infancy to as much as 80 per cent in adulthood. This means that the majority of IQ differences between adults can be attributed to inheritance.

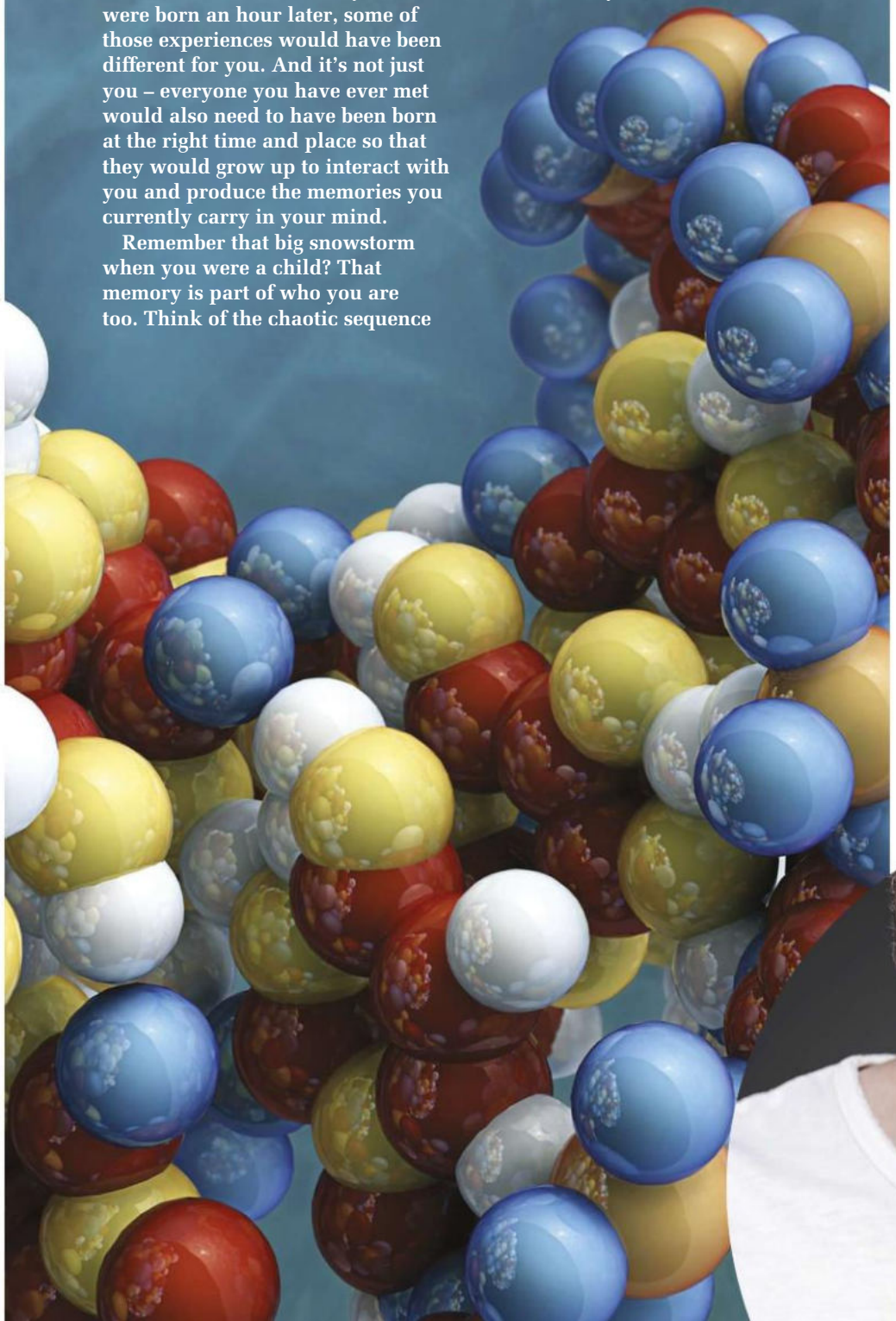
Upbringing, education, friends, health, and so on, influence academic success but genes play a very large part.

What is the probability of me being me?

The DNA of any two strangers never differs by more than 0.1 per cent. But that still gives around 10 million locations in your DNA that can vary.

But genetic variation isn't the only thing that makes you unique. Identical twins share the same DNA and yet they aren't the same person. Each of us is also shaped to some degree by everything that happens to us after we are born. If you were born an hour later, some of those experiences would have been different for you. And it's not just you – everyone you have ever met would also need to have been born at the right time and place so that they would grow up to interact with you and produce the memories you currently carry in your mind.

Remember that big snowstorm when you were a child? That memory is part of who you are too. Think of the chaotic sequence of events that led to that storm occurring on that particular day. Now multiply it by the chances that your mother got distracted at exactly the right moment for you to get lost in the department store that time. When you combine the odds of all of these thousands of formative experiences that define you, the probability of ending up with 'you' is effectively zero.



WHY ARE HUMAN BRAINS SO BIG?

WHY DO MEN GROW BEARDS BUT WOMEN DON'T?

Men grow beards because the hair follicles on their jaw are stimulated by the hormone dihydrotestosterone, which is produced from testosterone. Women have the same number of follicle cells on their faces as men, but these are less sensitive to dihydrotestosterone, and females also have lower testosterone levels. Beards may have evolved as a signal of the testosterone levels of a man, and women came to find thicker beards attractive because it implied strength.

One possibility is that large brains are sexier. The person that can make music and art, or tell stories, may be more attractive to potential mates. But in the 1990s, anthropologist Robin Dunbar suggested that humans might also need large brains to keep track of their complicated social lives. Human social circles normally comprise around 150 people, compared with 50 for chimpanzees. Larger social groups have exponentially more inter-relationships and our survival and success depends on being able to react to and predict the behaviour of our peers. Related to this is the idea of social dominance. Once our ancestors had begun to master their environment, their biggest threats were other humans. Leadership tussles within and between tribes favoured smarter humans much more than those that were just stronger.

PHOTOS: SCIENCE PHOTO LIBRARY X2, GETTY X2, ALAMY

How old are the genes in humans?

The genes in a modern human don't all date back to a single point in our history. When a new species evolves, it has almost exactly the same genes as its ancestors, with just a few crucial mutations that set it apart. The egg and sperm that originally created you probably contained 100 to 200 new mutations that weren't in your parents' DNA. Each of those mutations created a new gene, so you have quite a few genes that are only slightly older than you.

IN NUMBERS

33,000

protein-coding genes are present in the genome of the California two-spot octopus. In comparison, humans have fewer than 25,000.

Could two people who aren't twins have the same DNA?

As a species, humans actually show remarkably little genetic diversity. The DNA of two unrelated people only differs by about one in every 1,000 base pairs; orangutans differ by more than double this amount. Even so, there are three billion base pairs in the human genome, so that's an average of three million genetic differences between any two strangers. Most of these differences are 'single nucleotide polymorphisms' (SNPs), in which a single letter of the genetic code is changed. There are about 20 million known SNPs in the human genome. This means that the odds of someone having the same DNA by chance is like having a deck of 20 million cards, all different, and then drawing the same hand of three million cards twice!

Upside down

CIERVA COVE

ANTARCTICA

This giant hunk of gleaming ice is the underside of a recently overturned iceberg. When icebergs are irregularly shaped or melting, they can become imbalanced and flip over, releasing energies comparable to that of an atomic bomb.

"An iceberg will flip depending on its geometry as well as its density,' explains Justin Burton, Assistant Professor of Physics at Emory University, Atlanta. "If it's tall and skinny, it will tip over."

While iceberg flips rarely occur, increases in temperature due to climate change are making it more common.

The newly exposed underbelly of the iceberg has not been sullied by snow, debris or weathering, so light can shine through it more easily, giving it a vibrant, aquamarine hue.

"The blue colour means it came from depth and was formed under pressure," says Burton. Bubbles and air pockets were pushed out of the ice, meaning that the light can travel further into the iceberg before scattering. "The further it travels, the more red it absorbs and the bluer it looks."

PHOTO: ALEX CORNELL

WHY ARE THUNDERSTORMS MORE COMMON IN THE SUMMER?

The science of how thunderstorms are triggered is still somewhat mysterious. Thunderstorms require the formation of clouds, inside which regions of positive and negative electric charges can accumulate. These lead to voltage differences so big – around 400,000V per metre – that electrons are stripped off the molecules within the cloud, forming violent electric flows that we see as lightning.

Thunderstorms are more common during summer because the necessary conditions occur most readily when there's plenty of heat. Heat triggers convection, in which air becomes hotter, less dense and rises up from the surface. Plus, air holds most moisture when it's warm. While the processes that form the electric charges are not fully understood, it's believed to involve the interaction of violently rising moist air and ice crystals at high altitude.

In the UK, suitable conditions occur on only around half a dozen days during the summer.

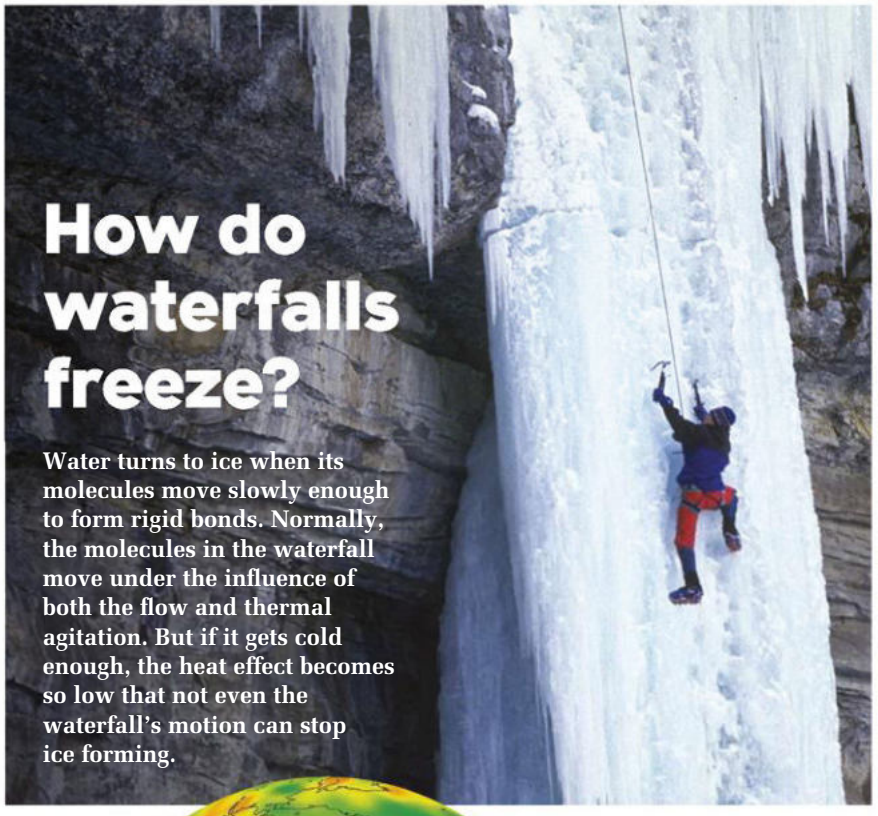
PLANET EARTH

The North Pole, population boom, climate change, thunderstorms, Pangaea, the Dead Sea, how life began, the world's longest rivers...

How many elements make up our planet?

There are 118 elements in the periodic table, 98 of which occur naturally. But just eight (iron, oxygen, silicon, magnesium, sulphur, nickel, calcium and aluminium) make up almost 99 per cent of Earth's mass. Carbon, present in every living thing, accounts for just 0.07 per cent of Earth's mass.

Elements 83 and above are radioactive and are gradually disappearing due to radioactive decay; above number 98, this decay is so fast that the elements are only found in the laboratory. The last element, ununoctium, is so unstable that only three or four atoms have ever been detected.

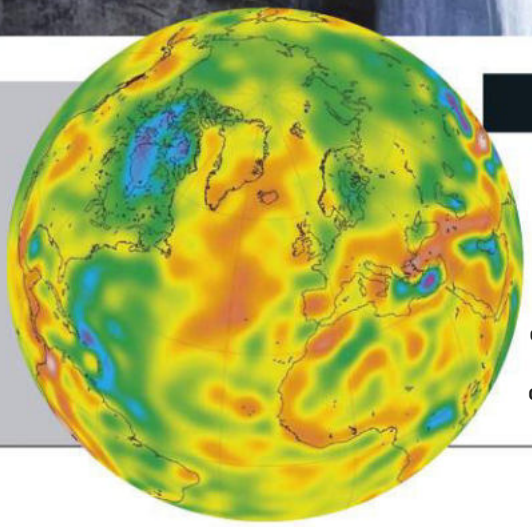


How do waterfalls freeze?

Water turns to ice when its molecules move slowly enough to form rigid bonds. Normally, the molecules in the waterfall move under the influence of both the flow and thermal agitation. But if it gets cold enough, the heat effect becomes so low that not even the waterfall's motion can stop ice forming.

DOES GRAVITY VARY ACROSS THE SURFACE OF THE EARTH?

As a rule of thumb, places near Earth's equator experience lower gravity than those near the poles, through the joint effect of the Earth's spin and equatorial bulge. Observations by satellites show that gravity is weakest in the Peruvian mountains. But, at less than one per cent below the global average, you'd never be able to tell.



IN NUMBERS

7.74

The time, in seconds, of the longest ever known lightning flash. It occurred in France in 2012.

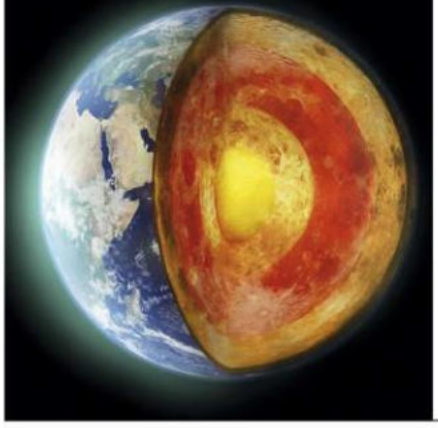
PHOTOS: GETTY X4, SCIENCE PHOTO LIBRARY

DID YOU KNOW?

The most densely populated city in the world is Dhaka in Bangladesh. There are 44,500 people in every square kilometre.

Will Earth's interior ever become solid?

Beneath us all is a seething cauldron of rock, wrapped round an iron-nickel core at temperatures similar to the surface of the Sun. Most of the heat comes from radioactive decay of elements like uranium in the surrounding mantle. As this process will continue for billions of years yet, the Earth is likely to have been destroyed by the death of the Sun before it can solidify.

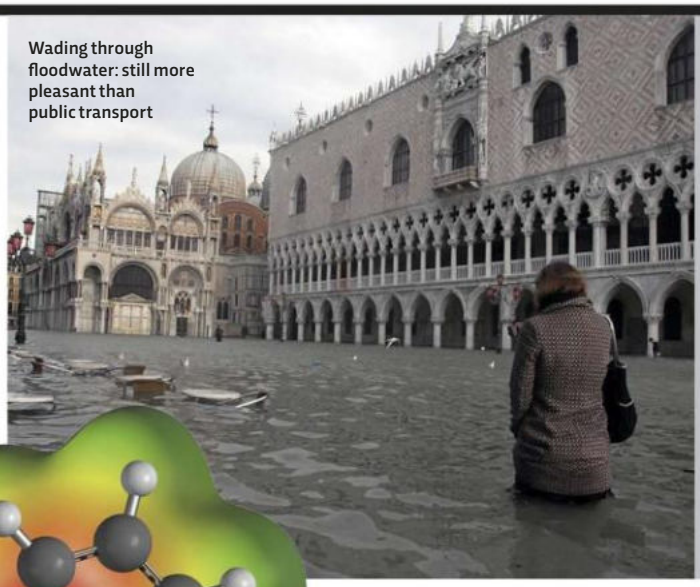


Can coral reefs recover from bleaching?

Coral bleaching occurs when warmer sea temperatures cause coral to expel the tiny algae that live in their tissues. Without these algae, corals are more susceptible to disease, with impaired growth and reproduction rates. If increased temperatures were short-lived, surviving corals can sometimes regrow their algae within a few months. When bleaching is localised, healthy coral nearby can also help repopulate the area. But in instances of more severe, extensive or repeated bleaching events, or when additional stresses such as pollution or ocean acidification come into play, large swathes of coral may die and recovery can take decades.

PHOTOS: GETTY X2, SCIENCE PHOTO LIBRARY, PRESS ASSOCIATION

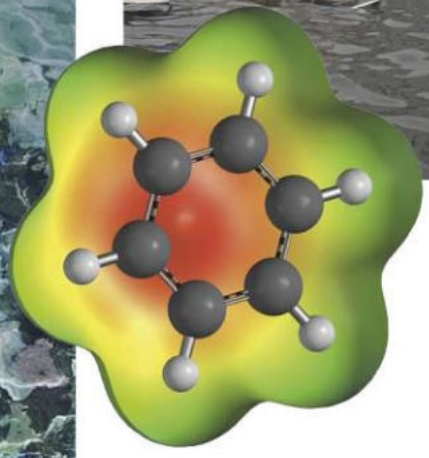
Japan's largest coral reef, Sekiseishoko, is starting to bleach and die because of higher sea temperatures



Wading through floodwater: still more pleasant than public transport

Is sea level rise accelerating?

Global sea levels rose by about 19cm from 1900 to 2010. Since 1993, satellites have helped make more precise measurements of sea level change. Between 1993 and 2010, sea level increased by just over 3mm per year, almost double the average pace for the 20th Century. As temperatures continue to soar, scientists expect sea levels to rise at even faster rates, resulting in a rise of up to 80cm by the end of the century.



Is water always necessary for life?

All known life needs liquid water to function properly. It's essential in part because water is such a good solvent, readily dissolving and transporting nutrients across a wide range of temperatures, and plays a key role in ensuring proteins behave properly. But scientists suspect alien life may have evolved to exploit other chemicals, like hydrocarbons, capable of doing the same job.

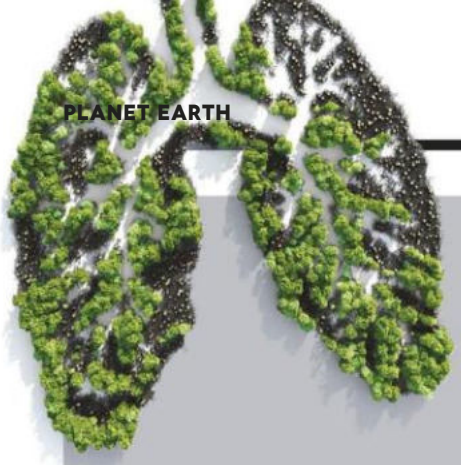
IN NUMBERS

30 metres

The height of the biggest wave ever surfed.

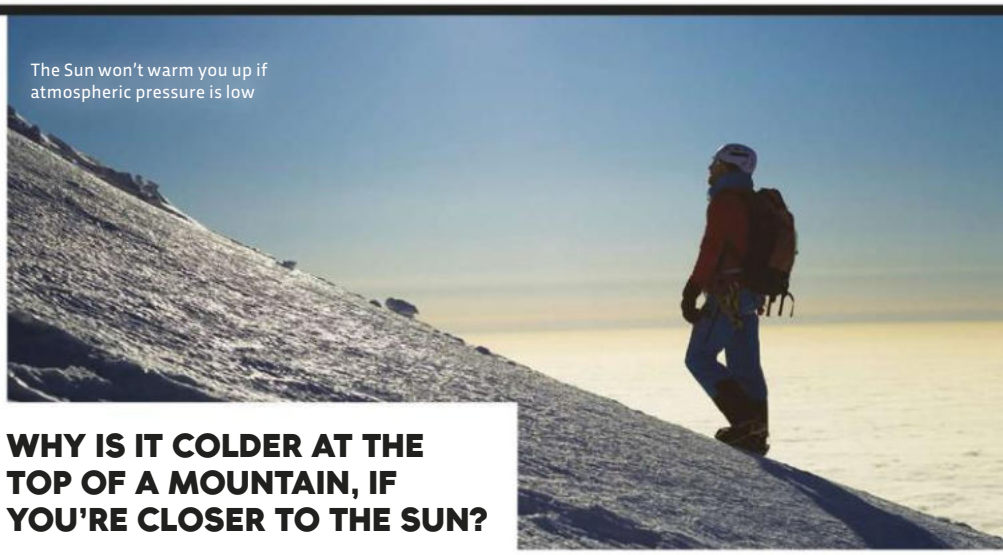
What would happen if all the glaciers melted?

Despite the effects of continuing global warming, a tenth of the planet's land mass is still covered in ice (compared with 32 per cent at the time of the last Ice Age). Glaciers form a large proportion of this frozen landscape and store around three-quarters of Earth's reserves of fresh water. If global warming ever became so extreme that all the glaciers melted, sea levels would rise by a beyond-catastrophic 70 metres.



Does Earth have a constant oxygen level?

No. The oxygen level has varied a lot in the past. It was 35 per cent during the Carboniferous period. But, as the climate cooled and land plants died off, it fell to 12 per cent by the beginning of the Triassic. Back then, the air at sea level would have felt thinner than at the top of the Alps today. Burning fossil fuels has only reduced oxygen levels slightly, and deforestation also has a small effect, as other plants grow in place of trees. But global warming will have a significant impact on marine plankton, which produce about 70 per cent of atmospheric oxygen.



The Sun won't warm you up if atmospheric pressure is low

WHY IS IT COLDER AT THE TOP OF A MOUNTAIN, IF YOU'RE CLOSER TO THE SUN?

As the Sun is around 150 million kilometres away, even being on top of Everest only brings you 9km closer – too small a difference to make you feel warmer. At these altitudes, barely 10 per cent of the atmosphere remains. As the air isn't so compressed, the air pressure is so low that the temperature falls to a lethally cold -55°C. In an airplane, passengers and crew are kept warm using hot air taken from the compressor stages of the engines before it's mixed with fuel.

IN NUMBERS

2,500

The distance, in kilometres, that autonomous sub Boaty McBoatface will travel under the Arctic sea ice.

Why is most of the world's landmass in the northern hemisphere?

The Greek philosopher Aristotle argued that there simply had to be a huge landmass south of the equator in order to balance out the vast amount to the north of the planet. The idea of 'Terra Australis' persisted for over 2,000 years and even appeared on maps between the 15th and 18th Centuries. It was finally debunked by Captain James Cook's expedition to find it in the 1770s.

It's now recognised that the continents aren't that important, being merely slightly thicker parts of the upper crust, which itself represents barely one per cent of the volume of the Earth. Satellite studies of the distribution of gravity across the entire planet reveal little difference between the amount of mass in the northern and southern hemispheres. As such, the arrangement of the world's continents has little significance – and, in any case, has changed over time. Around 200 million years ago, Earth's surface was dominated by the Pangaea supercontinent, much of which was actually south of the equator. Pangaea broke up over time to form the modern continents that we're familiar with today.

With the current rate of pollution, when will Earth become uninhabitable for humans?

It won't. Throughout history, as pollution levels have risen, we have taken action. The Great Smog of London in 1952, which killed 4,000 people, was followed four years later by the Clean Air Act. In the US, similar legislation has seen emissions of air pollutants fall by about 60 per cent in the last 35 years. The 1987 Montreal Protocol eliminated almost all CFCs from industrial and consumer products worldwide.

Leaded petrol and the pesticide DDT are also banned in most places. Air and water pollution are still a major problem in newly industrialised countries. But pollution is rising more slowly than when the West went through the Industrial Revolution, due to better awareness and technology. With care, it's possible that we may be able to sustain a habitable planet for humans more or less indefinitely.

PHOTOS: GETTY X2, SCIENCE PHOTO LIBRARY X2, PRESS ASSOCIATION, ALAMY

Does rain ever fall as pure water?

No. Water is an excellent solvent and rain always contains dissolved gases from the atmosphere. Even in a remote, pollution-free region, rainwater will still be slightly acidic because carbon dioxide in the air reacts with water to form carbonic acid. Rainwater isn't even pure when the raindrop forms, because each drop precipitates around a speck of dust, or an airborne bacterium.

TOP TEN

WORLD'S LONGEST RIVERS

FROM SOURCE TO MOUTH

1. Nile
6,695km
East and North Africa

2. Amazon
6,516km
South America

3. Yangtze
6,380km
China

4. Mississippi-Missouri
5,969km
USA

5. Yenisei
5,539km
Siberia

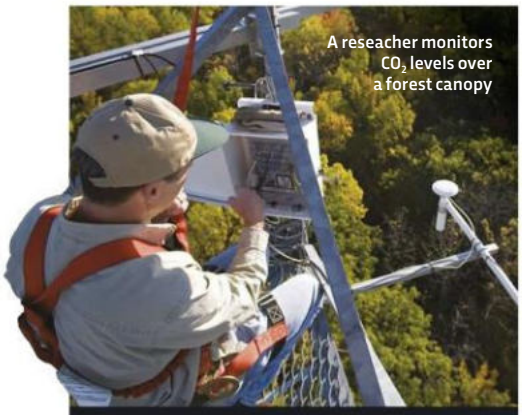
6. Yellow River
5,464km
China

7. Ob-Irtysh
5,410km
Siberia

8. Paraná-Rio de la Plata
4,880km
South America

9. Congo
4,700km
Central Africa

10. Amur-Argun
4,440km
North Asia



A reseacher monitors CO_2 levels over a forest canopy

Have we made any difference to climate change yet?

Quite possibly – but not in a good way. The principal drivers of climate change are greenhouse gases that trap the Sun's heat. The most important of these is carbon dioxide (CO_2), produced by human activities such as energy generation and transportation.

The good news is that 2014 saw CO_2 emissions from the energy sector remain static, suggesting the message about fossil fuels is finally getting through. The less good news is that as of May 2015 the total amount of atmospheric CO_2 exceeded the highest level recorded since scientific measurements began in 1958.

Perhaps most concerning of all is the fact that even if emissions of all greenhouse gases ceased entirely tomorrow, any warming would still persist for many centuries. This is partly because CO_2 lingers in the atmosphere for several centuries after release, and partly because the oceans are slow to respond to global warming, but are also just as sluggish to react to any cooling.

IN NUMBERS

1 metre

The amount by which the Dead Sea's surface level is dropping each year.

1,700

The height in metres of an underwater mountain, Anton Dohrn, off Scotland's west coast. In comparison, Ben Nevis is 1,344m.

How do drought balls work?

The warmer water gets, the faster its molecules move and the quicker it evaporates. By shielding water from sunlight and keeping it cool, drought balls (or shade balls) can slow evaporation. In 2014, 96 million of these plastic balls were released into Los Angeles' main reservoir to reduce microorganism growth, preventing the creation of bromate – a carcinogen that forms through a chemical reaction triggered by UV light. But the balls also reduced evaporation by up to 90 per cent.

On an alien planet, hydrocarbons could perform the same role as water

WHERE DID EARTH'S WATER COME FROM?

It's a bit of a mystery. Explanations divide into two camps: endogenous, meaning the water came from Earth itself, and exogenous, meaning it was dumped here from elsewhere. One endogenous possibility is that water molecules were formed from hydrogen and oxygen molecules combining inside the early Earth, and emerging as steam in volcanic eruptions. Alternatively, ready-made water molecules may have been delivered here by comets.

IS THERE A LIMIT TO THE HUMAN POPULATION ON EARTH?

The drought balls in Los Angeles will last for 10 years, and will then be recycled

How long until we run out of landfill space?

In the UK, estimates typically range from six to eight years. But local authorities have been saying this since at least 2010 and we aren't there yet. This is because EU directives have steadily increased the landfill tax, so councils have been driven to recycle more and more of their waste. In 2009, 90 per cent of our rubbish went to landfill. It's less than 50 per cent now and forecast to drop to 10 per cent by 2020.

In 2002, Harvard University sociobiologist Edward Wilson estimated that the amount of available arable land in the world would be enough to feed a maximum of 10 billion people. This assumed that they were all vegetarians. However, if everyone on the planet had the same eating habits as the average American, then there would need to be four Earths to support them. Drinking water may be more of a constraint since only three per cent of the Earth's water is freshwater and most of that is locked in ice caps or other inaccessible places.

In principle, these problems could be overcome. Earth receives more energy from the Sun in an hour than humanity uses in a year. If we harnessed more of this energy, we could produce drinkable water from the sea (through desalination) and create food from bacteria or algae.

But this assumes that our species will multiply indefinitely – and that isn't borne out by current trends. While global population is predicted to reach 9.7 billion by 2050 and 11.2 billion by 2100, according to the United Nations' Population Division, the rate of population growth has been falling since 1963.

As countries become more industrialised and infant mortality rates fall, birth rates seem to drop as well. The limit to human population may be our own desire to reproduce, rather than Earth's capacity to support us.

PHOTOS: GETTY X2, SCIENCE PHOTO LIBRARY X2, EYEVINE

WHO REALLY DISCOVERED?

THE NORTH POLE

ROBERT PEARY

DR FREDERICK COOK

For many years that accolade went to the US explorer Robert Peary, who claimed to have reached the North Pole on 6 April 1909. Yet even at the time his claim was disputed. Dr Frederick Cook, a rival American explorer, insisted he had reached the pole almost a year earlier. But neither of them could provide definitive proof. Cook's own evidence was rejected by an independent commission, while Peary refused to hand over any details at all.

In 1989, the US National Geographic Society announced that an analysis of photographs taken by Peary, together with his records of ocean depths and other data, were consistent with his expedition getting within eight kilometres of the true pole. Cook's claim, meanwhile, has always been dogged by suspicions of fraud.

In the following years, airborne and submarine expeditions reached the North Pole. But the first undisputed expedition to reach the North Pole over the surface was not until 1968, when the American Ralph Plaisted and three companions arrived on snowmobiles. On 6 April the following year, the British explorer Sir Walter (Wally) Herbert became the first to reach the North Pole on foot.

What is the greenest energy source?

All renewable energy sources are strong contenders for the title of 'greenest energy source' since they harness carbon-neutral sources of energy such as the Sun or wind and don't cause air pollution, putting them leagues ahead of coal or gas power. But picking a clear winner is tricky. Once you consider the emissions associated with their manufacture and installation.

The PS10 Solar Power Plant is located in Spain. A total of 624 mirrors concentrate the Sun's rays onto a solar receiver on the top of the tower

ARE THE OCEANS GETTING SALTIER?

Seawater tastes salty because of the action of rain on exposed rocks. The compounds most likely to find their way into the sea are the most water-soluble ones that are rich in chlorine and sodium ions. There's no doubt oceans have got saltier over time. The real mystery is why they aren't now saturated with salt, making them as lifeless as the Dead Sea. Somehow, the concentration has remained at just a few per cent for at least half a billion years. One theory proposes water evaporates off vast, mat-like colonies of bacteria in coastal lagoons, leaving salt trapped on the coast and unable to dissolve back into the sea.

The Dead Sea is about 10 times saltier than normal seawater

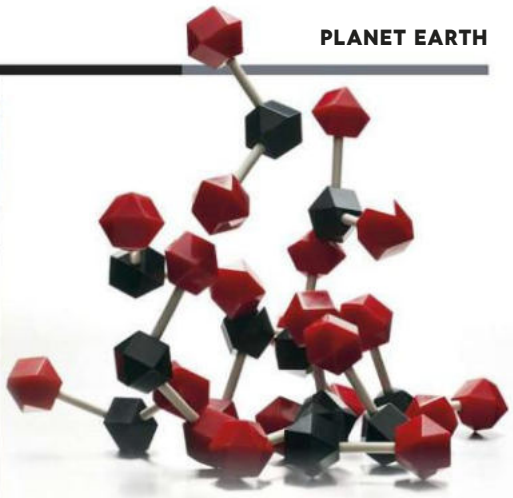
HOW DID LIFE ON EARTH BEGIN?

Did life on Earth start at hydrothermal vents, or did it arrive on a comet?

One hypothesis is that the iron sulphide spewing from deep-sea volcanic vents precipitated into a solid mass with lots of tiny chambers where simple biological molecules could become concentrated and assemble, using energy from iron redox reactions.

The 'panspermia hypothesis', on the other hand, suggests that living cells or spores may have arrived fully formed travelling on comets from outer space. Recent research by Prof John Sutherland at Cambridge University offers a possible compromise between the two: comet impacts may have delivered hydrogen cyanide, which reacted with the hydrogen sulphide already on Earth to form the earliest building block molecules. That then assembled to form RNA.

PHOTOS: GETTY X3, SAM FALCONER



Could captured CO_2 be stored in the deep ocean?

Capturing carbon dioxide (CO_2) to stop it boosting global warming seems a good idea, but raises the problem of where to store the stuff. One low-cost solution is simply to pump it into the deep ocean, but CO_2 is toxic to marine life and would also combine with the seawater to produce an acid, which would pose unknown environmental risks. Underground or sub-seabed storage are thought to be less risky options.

Is there life in clouds?

Yes. Up to two million tons of bacteria are lofted by air currents into the atmosphere each year, along with 55 million tons of fungal spores and an unknown quantity of algae. These microscopic life forms are thought to play an important part in the weather by causing the water vapour in clouds to precipitate into rain more often than it would in a lifeless atmosphere.

Going with the flow

MOUNT KILAUEA, HAWAII

USA

Now this really is a hot shot. The gently glowing lava flows of Mount Kilauea volcano, Hawaii are capped by the faint streak of a shooting star, the sprawling majesty of the Milky Way and a gleaming full Moon.

"What's special about the volcanoes of Hawaii is that they sit on a giant hotspot, which is the origin of the very islands themselves," says Prof Dougal Jerram, a volcano expert and BBC presenter. "A hot plume of material from deep within the Earth feeds the volcano and, as the Pacific plate slowly moves over this hotspot, you get the chain of Islands that form the Hawaiian archipelago."

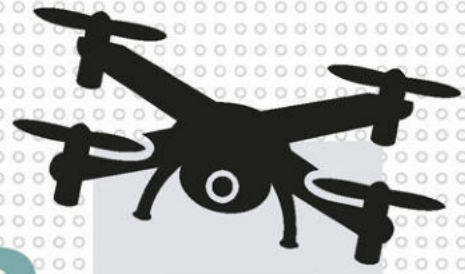
Mount Kilauea is the most active volcano on Earth – its current eruption has lasted for more than 30 years. Its gently sloping landscape means that the incandescent lobes of lava which it produces are slow-moving but expansive.

"Each lobe breaks out from a previous one and flows like hot treacle, making a characteristic folded, rope-like texture on the surface, which is named by an Hawaiian word 'pahoehoe'," says Jerram.

PHOTO: MIKE MEZEUL II

IN THIS ISSUE...

Discover the science behind everyday life



6km

The distance from which the **world's highest resolution camera** can capture individual people (PAGE 47)

300 HOURS

The amount of video uploaded to YouTube every minute

(PAGE 46)

7 million

The number of drones forecast to be sold in the US in 2020

(PAGE 39)

30cm

The length of the world's largest spider

(PAGE 68)

95,000km

THE LENGTH OF BLOOD VESSELS IN THE AVERAGE HUMAN BODY (PAGE 10)

110km/s

The speed at which the Andromeda Galaxy is approaching the Milky Way

(PAGE 29)

Astronauts on the ISS do a **'number 2'** by **'docking'** themselves over a **hole**

(PAGE 35)

20-25%

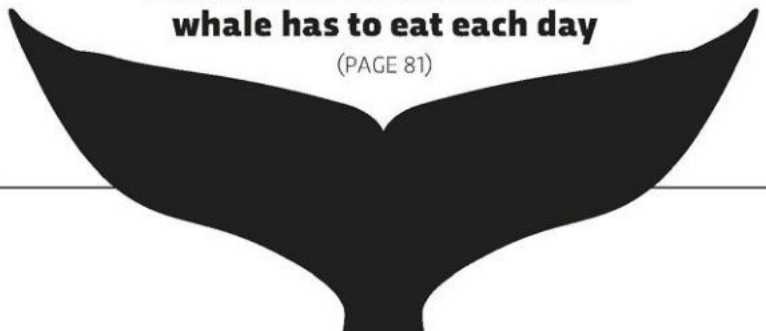
The percentage of your body's energy used by your brain

(PAGE 13)

1.5 million

The number of calories a blue whale has to eat each day

(PAGE 81)



OVER 80%

OF MATTER IN THE UNIVERSE IS 'DARK MATTER'

(PAGE 35)

WHY DO WE DREAM?

WHAT TIME IS IT ON THE MOON?

IS IT POSSIBLE TO DELETE A SENT EMAIL?

HOW DO STONES SKIM?

HOW DO SHARKS SMELL BLOOD UNDERWATER?

DO IDENTICAL TWINS THINK ALIKE?

WHY DO SWEATY FEET SMELL OF CHEESE?

IS A BLACK HOLE REALLY A HOLE?

COULD MY PET CATCH MY COLD?

WHY DO MEN GROW BEARDS BUT WOMEN DON'T?

IS WATER ALWAYS NECESSARY FOR LIFE?

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CAN WE UNLEARN THINGS?

HOW DO ASTRONAUTS KEEP CLEAN?

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HOW CAN WE MAKE CARS MORE ENERGY EFFICIENT?

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COULD WE CLONE A MAMMOTH OR A DINOSAUR?

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DOES THE SPEED OF LIGHT EVER CHANGE?

DOES SUNSHINE REALLY MAKE US HAPPIER?

WHAT IS THE GREENEST ENERGY SOURCE?

WHY DO DOGS BURY BONES?

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